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THE PHYSICAL BASIS OF SOCIETY

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THE PHYSICAL BASIS OF SOCIETY

BY
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SECOND EDITION

D. APPLETON AND COMPANY
NEW YORK LONDON
1928

HM
208
.K4
1928

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PRINTED IN THE UNITED STATES OF AMERICA

PREFACE

> As to wisdom, a man ain't a spring, he's a tank, an' gives out only what he gathers.
>
> —*Sayings of Si Sylvanne*

When this work was first published, it contained little more than the lecture notes of the author, and the reader bumped along from fact to fact. In this edition the facts have not been reduced, but enough ballast has been supplied to make the trip a bit more smooth. The book has been wholly rewritten, though some of the original text and illustrations have been incorporated.

This work is intended for those who want facts, not style. The author seeks to interest serious students and to make them desirous of knowing at first hand the writers from whom the illustrative material has been drawn. To him who will turn to the specialists many delightful and profitable hours can be promised. This work, then, is meant to be an introduction, not a substitute.

The author's conviction that students of social science cannot afford to neglect the underlying earth has grown with the years. He has found that the ablest students are always most interested in the discussions. The World War must have opened the eyes of many people who had not considered these matters previously. As passions cool, it must be increasingly evident that it takes more than a mad Kaiser to make a war and that reformers, prating of liberty, may follow the methods of tyrants. Since the position America occupies to-day is so largely due to physical factors, it is more than ever important that Americans should see things in terms of the world as a whole.

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Again the author disclaims any originality. He has scouted over a wide field to find the best accounts and to combine them into a general sketch. Like Charles Reade, when accused of plagiarism, he must reply, "I have milked three hundred cows for it, but the butter I make is mine." He has sought to give full credit and is regretful if his memory has failed him at times.

In a well known and excellent work on the author's desk there is not a single reference to any source. Yet by no stretch of imagination could its writer have made one per cent of the discoveries mentioned. Here the other method of allowing the authorities to speak for themselves is followed even if smoothness be sacrificed. No one man could know intimately all the ground covered.

Many will be struck by the omission of the psychological base. No one questions its importance but too many additional chapters would have been necessary to give it adequate treatment.

At least two colleagues of the author on the staff of the University of Pennsylvania have read and criticized every chapter. To them, as well as to many others, the author is heavily indebted, and to all these he gives his sincere thanks. He, however, accepts full responsibility for all errors of fact or emphasis which may be found. To the authors and publishers who have courteously granted permission to use quotations or illustrations, he is likewise grateful.

To any teacher who may consider using this material in the classroom the author would say that the surface can be skimmed in half a school year with a class meeting at least twice a week. Special emphasis should be laid on local conditions. Make the student apply the principles to home conditions. Do not try to cover the earth.

Is this sociology? The author neither knows nor cares. That is a question of definition. Our life is a unity. Here we have sought to correlate a lot of material fundamental in its relation to all our social life. This material exists in widely scattered volumes. Someone must collect and organize it if the student is to have a comprehensive view. The facts are gathered in the earlier chapters. The few last brief sections but seek to sketch the social situation and to indicate the connection between nature and society. No attempt has been made to do more than to present the problems.

The author is most grateful to his associate Dr. Donald R. Young for reading the page proof and preparing the index.

C. K.

CONTENTS

PAGE
Preface v

PART I

NATURE IN CONTROL OF MAN

CHAPTER
I. The Earth and Its Elements 3
  The Solar Universe 3
  Chemical Elements of Matter 7
  Chemical Composition of the Earth's Crust and Atmosphere 8
  Geological History of the Earth 17
  The Geological Time-Table 25
    Present Time 25
      Psychozoic Era 25
    Geologic Time 26
      Cenozoic Era 26
      Mesozoic Era 26
      Paleozoic Era 26
      Proterozoic Era 26
      Archeozoic Era 26
    Cosmic Time 26
      Formative Era 26

II. Life, Its Nature and Distribution 30
  Organic Compounds 31
    Primitive Protoplasm 32
    Temperature of Organisms 34
    Properties of Water 35
    Carbon and Its Compounds 36
  Organisms as Chemical Engines 38
  Physical Environment of Organisms 40
    Topography 40
    Climate 42
    Air and Water Currents 43
    Moisture 44

CHAPTER PAGE
Distribution of Organisms 45
  Bacteria 45
  Plant Distribution 46
  Influence of Rainfall 47
  Animal Distribution 48
  Influence of Snow 49
  Influence of Temperature 50
  Influence of Wind 54
Organic Activity 55
Dangers of Changes 58
Rhythm in Nature 59

III. HUMAN GEOGRAPHY 61
Man's Adaptation to Environment 62
  Race and Climate 63
  Whites in Tropics 65
World Population 68
Influences of Nature upon Man 69
  Physical Effects 69
  Influences on Occupations and Activities . . . 71
  Influences on Migration and Commerce . . . 74
  Psychical Influences 75
Civilization and Climate 78

IV. MUTUAL AID AND THE STRUGGLE FOR EXISTENCE . . 85
The Organic Complex 85
  Effects of Plants 86
  Effects of Microörganisms 87
Organic Processes 89
  Bacterial Chemistry 89
  Soil Formation 91
  Bacteria in Man 91
Forms of Association 93
  Symbiosis 94
  Commensalism 94
  Parasitism 95
Repopulation of Devastated Areas 95
How Animals Serve Plants 96
Rate of Reproduction 98
The Balance of Life 99
  Checks to Increase 100
  Food Habits 103
  The Struggle for Existence 104
  Animal Associations 105

CHAPTER PAGE
Insect Associations 108
Mutual Aid 109

V. MAN, A DISTURBING FACTOR 111
Man Upsets the Balance of Nature 111
The Warfare of the Future 111
Man's Increased Needs 112
Primitive American Fauna 114
Depletion of Food Supplies 115
Extermination of Reptiles 117
Destruction of Bird Life 118
Destruction of Animals 120
Benefits of the Upset 122
Problems of the Food Supply 122
Protecting Domestic Animals 123
Protecting Poultry 124
Control of Weeds 126
Insects the Great Enemy 127
Cotton Boll Weevil 128
Corn Borer 129
Japanese Beetle 129
Gypsy Moth 130
Scale Insects 131
Crop Damage by Insects 132
Methods of Attack on Enemy Insects 133
Birds and Man 133
Bird Census of the United States 134
Birds as Seed-Eaters 135
Birds as Grain-Eaters 136
Birds as Insect-Eaters 136
Insect Parasites 138
Rodent Pests 138
Mice 139
Rats 139
Difficulties of Pest Control 140
Effects of Bird Destruction 140
Unsatisfactory Remedies 141
Rabbits 142
Cats 143
Disease 143
Needless Slaughter 144
Bird Protection 144
Man versus Insects 145
Insect Societies 145
Summary 146

PART II

MAN IN CONTROL OF NATURE

CHAPTER PAGE
VI. Domestic Plants and Animals 151
  Domestication of Animals 152
    Cattle 153
    Horses 154
    Camels 156
    Sheep 156
    Goats 157
    Elephants 157
    Swine 158
    Reindeer 159
    Dogs 159
    Cats 160
    Llamas 161
    Geese 162
    Ducks 162
    Chickens 163
    Guinea Hens 163
    Turkeys 163
    Pigeons 164
    Ostriches 164
    Bees 165
    Silkworms 165
  Cultivation of Plants 166
    Plant Sources 167
    Tropical Fruits 169
    Tomato 170
    Fiber Plants 170
    Sugar 171
    Rubber 172
    Drugs 173
    Ornamentals 174
  Significance of Domestication 175
  Possible Utilization of Bacteria 176

VII. Man and His Machines 178
  The Development of Culture 178
    Early Discoveries 179
    Early Metals 179
    Later Metals 180
    Limited Supply of Metals 181

CHAPTER PAGE

Culture and Invention 182
The Metals 183
Iron Supply 183
Iron Alloys 184
Steel 185
Iron Production 185
Copper 186
Zinc 187
Aluminum 187
Tin 187
Lead 188
Noble Metals 188
Other Elements of the Machine Age 190
Fire-Making 190
Matches 191
Light 191
Fuel 192
Coal Mining 193
Chimneys 194
Engines 195
Wind and Water Power 196
Electricity 196
Petroleum 197
Gasoline 198
Silicon 199
Mechanical Slaves 199
Man versus Machine 200

VIII. THE CONQUEST OF DISEASE 202
The Attack through the Ages 202
Early Remedies 203
Beginnings of Medical Science 204
Galen 205
Suggested Causes of Disease 206
Beginnings of Bacteriology 207
Pasteur 207
Koch 209
The Germ Theory 209
The Pathogenic Bacteria 210
The Conquest of Specific Diseases 212
Smallpox 212
Yellow Fever 216
Malaria 220
Hookworm 223
Typhoid Fever 224

CHAPTER PAGE
Tuberculosis 225
Cholera 227
Bubonic Plague 227
Anæsthetics and Germicides 228
The Death Rate 231
Increase in Life Span 232
Plant and Animal Diseases 233
Diseases of Plants 233
Diseases of Animals 234

IX. Population and the Food Supply 237
The World Population 237
Population Movements 238
Resources and the Standard of Living 239
The Cause of Migrations 240
The Problem Defined 242
Malthus 242
East's Summary of the Present Situation 243
The Situation in the United States 247
Our Food Supply 250
Per Capita Food Production 253
Food Exports and Imports 255
Forest Resources 256
Forest Destruction 259
Plant Breeding 260
Metal Supplies 261
Indefinite Increase of Population Impossible 262
The Birth Rate 264
Is There a Solution? 265

PART III

MAN TRIES TO UNDERSTAND

X. The Ascent of Man 269
The Infinite Variety of Living Things 269
Man Asks Why? 270
Theology versus Science 270
Species 272
Hybrids 273
Varieties 273
Fossils 273
Geographical Distribution of Life 275
Variation 276

CHAPTER PAGE

The Explorers of Evolution 276
  Linnæus 276
  Buffon 277
  Erasmus Darwin 278
  Lamarck 279
  Charles Darwin 280
  The Idea of Evolution 281
Darwinism 282
  Pangenesis 283
  Sexual Selection 283
  Natural Selection 284
  Protective Coloration 284
Evidences for Evolution 286
  Paleontology 286
  Morphology or Comparative Anatomy 287
  Serology 289
  Geographical Distribution 289
  Embryology 290
  Genetics 291
The Ladder of Life 291
  Evolution Accepted 292

XI. HEREDITY 295
Cells and Their Functions 295
  Multiplication and Growth 296
  Specialization of Function 297
  Chromosomes 297
  Body Cells and Germ Cells 298
The Explorers of Heredity 300
  De Vries 300
  Mendel 301
  Correns 303
The Mechanism of Heredity 305
  Unit Characters 306
  The Germ Cell 306
  The Gene 307
  Linked Characters 308
  Mutants 311
  Sex Linkage 312
  Inheritance of Acquired Characters 313
  External Influences on the Germ Cell 315
  Heredity and Environment 318
  Biometrics 320

CHAPTER PAGE
XII. PROBLEMS OF HUMAN HEREDITY 323
  Inheritance of Physical Qualities 324
  Inheritance of Mental and Nervous Inferiority . . 329
    The Feeble-Minded 329
    Insanity 336
    Epilepsy 340
  Inheritance of Mental Superiority 341
    Environment and Achievement 343
    Specific and General Ability 345
    Genius and Eminence 346
  Eugenics 351
    Sterilization of the Unfit 352
    Breeding from the Best Strains 354

XIII. SEX AND SOCIETY 357
  Sex in Lower Organisms 357
  Sex Differentiation 358
  Relative Numbers of Males and Females 360
  Sex Determination 361
  Physical Differences between the Sexes 363
  Special Functions of the Female 367
  Alleged Mental Inferiority of Women 368
  Division of Labor between the Sexes 370
  The Position of Women in Society 371

XIV. RACE DIFFERENCES 375
  Principles of Race Classification 375
    Limitation to Physical Traits 375
    Early Classifications 377
    Blumenbach's Classification 378
    Race Criteria 379
  Human Origins 381
    Early Remains 381
    Neanderthal Man 382
    Cro-Magnon Man 383
    Modern Races 383
      1. The Mediterranean 383
      2. The Nordic 383
      3. The Alpine 384
      4. The Dinaric 384
    Primary Races 384
  Head Form as a Criterion of Race 387
    The Races of Europe 387
    The Nordic Theory 388
    Does Head Form Change? 389

CHAPTER PAGE
The Social Problems of Race 390
Race Prejudice 390
The Mentality of Negroes 392
Race Mixtures 397
Race Pride 402
Is Classification Possible? 400
A Typical American 406

PART IV

PHYSICS AND POLITICS

XV. Is Civilization Self-Destructive? 411
Degenerative Factors in Modern Civilization . . . 411
Counterselection 411
Industry and Health 412
Accidents 413
Monotonous Work 413
Antisocial Selection 414
Population Problems 415
The Declining Birth Rate 415
Marriage Rates 417
Marriage in the United States 419
Differential Birth Rates 419
Family Degeneration 420
Causes of the Declining Birth Rate 421
Migrations 422
Celibacy 422
Childlessness 423
Abortion 423
Contraception 424
Problems of Social Control 424
Prohibition 424
War 426
Caste 427
Philanthropy 428
Homicide 429
The Charges Against Civilization 430
Biological and Social Remedies 430
Physical Imperfection 431
Bad Morals 433

XVI. Social Institutions 435
What Society Is 435
Group Standards 436

CHAPTER PAGE
Classes of Social Institutions 438
Institutions as Agencies of Social Control . . . 440
Institutions to Serve Human Needs 443
Social Change 445

XVII. THE CONCEPT OF PROGRESS 449
Attempts at Definition 449
The Great God Progress 449
Ideas of Middle Ages 450
What Is Progress? 451
Perils of Biological Analogies 452
Criteria of Progress 453
Progress Measured by Achievement 453
Knowledge 453
Refinement of Manners 455
Social Virtues 455
Social Classifications 456
The Course of Culture 457
Scientific Research 458
Human Inconsistency 459
Progress Is Not Inevitable 462
Morals 462
World Unity 463
After Progress, What? 464

XVIII. THE COSTS OF CHANGE 465
Prosperity and Virtue 465
Change as a Source of Social Problems 466
Changing American Conditions 467
Local Contrasts 468
City versus Farm Life 470
Wealth 471
Industry 471
Taxation 472
The Home 473
Suggested Remedies for Social Maladjustments . . 473
Can We Go Back? 474
The Reactionary Attitude 475
The Radical Attitude 475
Change Is Dangerous 476
The Way Out 476

XIX. THE SPREAD OF CULTURE 478
Culture Diffusion 479
Culture Absorption 481

CHAPTER PAGE
Europeans 481
Civilization a World Product 483
Culture Centers 483
The Progress of Science 485
Research 486
Nature and Man 487

NAME AND SOURCE INDEX 503

SUBJECT INDEX 511

ILLUSTRATIONS

FIGURE PAGE

1. Seasonal variations in health and energy in Connecticut and Pennsylvania 80
2. Distribution of energy on the basis of climate 83
3. Food relations of aquatic animals 101
4. Mortality from yellow fever in Havana 218
5. Decline of yellow fever in the Western Hemisphere during the last quarter-century 219
6. Death rate from tuberculosis in the United States registration area 226
7. Death rate from all causes in the United States registration area 232
8. Land capable of use for crops 248
9. Utilization of the land area of the United States . . . 249
10. Potential uses of land area of the United States . . . 251
11. Average yields per acre, 1909-1913, of seven important crops in four European countries expressed in percentage of average yields in the United States 253
12. Yearly averages of cotton production, consumption, and exports in the United States, 1920-1924 256
13. Per capita acreage of forest land contrasted with that of improved land in the United States, 1850-1920 . . . 256
14. Average annual removal of standing timber in the United States through waste, destruction, or use 257
15. Average annual removal of standing timber from the forests of the United States assigned to various types of use or causes of destruction 258
16. Continuous variation. Discontinuous variation 301
17. Color inheritance 304
18. Suggested explanation of color inheritance in guinea pigs 305
19. The relations between successive generations 314
20. The inheritance of hæmophilia 326
21. The inheritance of polydactylism 327
22. The inheritance of dwarfism 327
23. The inheritance of deaf-mutism 328
24. The inheritance of feeble-mindedness 333
25. The inheritance of feeble-mindedness 334
26. Contrast in children of two marriages 335

FIGURE PAGE
27. Neurotic inheritance 336
28. Examples of the inheritance of insanity drawn from hospital experience 337
29. Guyer's case of the inheritance of insanity 339
30. The distribution of intelligence 342
31. The inheritance of great ability 348
32. The inheritance of low ability 349
33. The inheritance of ability, in the Wedgwood, Darwin, and Galton Families 350
34. "The typical American boy" 406
35. The declining birth rate in Europe 416
36. The families of 461 leading American scientific men . . 425

PART I

NATURE IN CONTROL OF MAN

THE PHYSICAL BASIS OF SOCIETY

CHAPTER I

THE EARTH AND ITS ELEMENTS

> Listen, first, while I sing the fourfold root of
>   creation,
> Fire, and water, and earth, and the boundless height
>   of the æther,
> For therefrom is begotten what is, what was, and
>   what shall be.
>
> —Empedocles

How little the average man knows is apparent to every one except himself. How much he can know is a matter of uncertainty about which he is not disturbed. That the wisest man knows but little is the conviction of every ignoramus. On one thing all are agreed; complete knowledge is far from us. Yet the story of the growth in human understanding is the most fascinating as well as the most important thing in human history. The stars shone on the curious animals of ages past but we do not know that the animals saw the stars. The primitive savage, peeking upwards through the leaves of the trees, got glimpses of them but we do not know what he thought about them. At some far later time the "watchman upon the mountain tops," "the shepherds keeping watch over their flocks by night," began the careful observations which led to the science of astronomy.

The Solar Universe

By the middle of the second century B.C. a Greek writer, Hipparchus, was able to list some 1,080 stars. He knew the length of the year and the time of the revolution of five planets about the sun. He knew that the solar system was moving toward the east, as compared to the stars, and was able to determine latitude and longitude. It is obvious that he could not have made all these discoveries himself.

Three centuries later, Ptolemy of Alexandria collected all the known facts in a treatise. He rejected the idea of Hipparchus that the earth turns on its axis, though he admitted that this would simplify the explanation, and he held that the earth was the center of the universe and that the heavens were in revolution. This concept of an earth-centered universe dominated for a thousand years. The ideas of the revolution of the earth on its axis and of the rotation of the planets about the sun were revived by the Polish priest and physician, Copernicus (1473-1543). About 1600, the telescope was invented in north Europe. There is much dispute as to the actual inventor. Galileo (1564-1642) heard of this and constructed one for himself with lenses about two inches in diameter. With this he made discoveries so marvelous that he got in trouble with the authorities, but, nevertheless, he overthrew the Ptolemaic interpretation and began a new epoch in human thought. Yet, Hipparchus, like men of to-day, would have said, "I told you so."

The earth, then, is but one of several planets, and by no means the largest, revolving about the sun. The stars which we see are other suns with other planets perchance revolving about them. Our minds are bewildered. We cannot comprehend space without limit nor can we postulate a limit as the ancients did with their idea of a solid firmament, the sky. With improved methods of measurement the distances are seen to be so great that we must figure them in light years rather than miles. It takes the light about four hours to go from the sun to Neptune but it must spend some four years to reach us from the nearest star (Alpha Centauri). If one prefers, let him try to visualize a light year as about six million million miles. It takes light about 10,000 years to reach us from the outer edge of our stellar system, but the end is not yet, for in 1926 Hubble announced the discovery of another system of suns some 700,000 light years away. The naked eye can see upwards of 4,000 stars while the great telescope at the Mt. Wilson Observatory will reveal nearly 500,000,000. If we use photographic methods another billion reveal themselves and astronomers believe that many billion more exist. Confronted by such numbers the Psalmist's query, "What is man that Thou art mindful of him?" takes on added meaning.

Patient study and repeated observations have given us some idea of the size of these stars. The diameter of the sun is about a hundred times that of the earth, some 800,000 miles, with a mass some 300,000 times that of the earth. The sun is a pygmy after all. Betelgeuse is a gaseous star less dense than our air, but with a diameter of 300,000,000 miles. The sun is bright but Rigel gives about 10,000 times as much light. But the sunlight reaches us in eight minutes while that from Rigel is 400 years on the way.

The discovery that the earth was but one out of countless worlds naturally suggested that its own history must have been the same as that of the others. When the comets and nebulæ were studied and found to be gaseous rather than solid, and when it was realized that many of the stars were in the same condition, it was easy to imagine that such was the origin of our solar system. To Laplace, in 1792, goes the honor of the suggestion of the "nebular hypothesis." In substance this is that a vast nebula once occupied the entire area of our solar universe. In the process of condensation the various planets and their satellites broke away and gradually cooled while the central sun still retains a large part of its heat. This theory was generally accepted throughout the nineteenth century. It does not fit all the facts known to-day and is being replaced by some of the "planetary" theories such as that of Chamberlin. This agrees with the older explanation in holding that the earth has split off from the sun but claims that at the time of the separation the earth was gaseous and not hot. To itself the earth attracted much new matter from surrounding space just as the meteorites fall on it to-day. The later process of condensation produced an enormous amount of heat and caused the molten condition. We know that the process of cooling has not been uniform and that there have been a number of glacial epochs when North America as far south as the Missouri and Ohio rivers was covered with ice, and there is evidence of older glaciations elsewhere. The discovery of the radioactive substances raises other doubts. Barrell claims that "if they extend in their surface amount to a depth of 40 miles, they must supply heat to the surface as fast as it is lost by radiation into space. The earth therefore appears not to be growing colder, though losing heat." [1] One of the best of living students, Joly, thinks it quite possible that the heat developed by condensation may again produce a molten globe, or even cause an explosion great enough to tear the earth into pieces through the accumulation of radioactive energy.

It is no longer believed that the earth has a thin skin of crust over a molten center, nor that volcanoes furnish vent-holes to the lower inferno. Volcanic phenomena are thought to be due to chemical changes relatively near the surface.

The invention in 1860 of that wonderful instrument, the spectroscope, has given us much added information about the stars. It shows us that the surface temperature of the sun is about 6,000° C. or 10,800° F. "We see carbon dazzling in the crater of the electric light, but the sun is far hotter than that. The sun is so hot that if the carbon stick of the arc lamp was thrust into its depths, the carbon would burst into gas with an explosion." [2] If, however, we compare the sun with other stars it is relatively cool. There are two stars in the constellation of Argo whose spectra show lines belonging to no known element but bearing such a relation to hydrogen that they are called protohydrogen stars. Helium is present with hints of magnesium and calcium. Taurus and Algol (known as helium-gas stars) show helium along with hydrogen, carbon, oxygen, and nitrogen. The protometallic stars such as Rigel and Sirius reveal such metals as iron, copper, and calcium. The metallic stars, including the sun, Arcturus, and Aldebaran, display the common metals. There are stars so cool that they have fluted spectra which do not show the characteristic lines of their elements. While man cannot rival in his laboratories the conditions of temperature and pressure found in the stars, he can reproduce some of them and by comparing his results with the revelations of the spectroscope, he gets some glimpses of the process of the formation of matter. The significance of this will appear later. It is most interesting to note that all the available evidence shows that the stars contain the same elements found on earth and no others, unless an exception be made of a substance called coronium known only by lines in the solar spectrum and which has not been found on earth. Under the peculiar conditions existing then, in bygone ages, the various substances found on earth as well as in the stars have been created. Further evidence is supplied by the meteorites, composed for the most part of iron, that fall on earth.

Chemical Elements of Matter

There is reason to believe that matter on earth exists in ninety-two different forms to which we give the name of elements. Of these about ninety have been identified and named although the last three to be discovered are known only through the spectroscope and have not been isolated as yet. These bear the names of masurium, rhenium and illinium. In pre-Christian times only nine were known, of which seven were metals, gold, silver, etc.; the others were carbon and sulphur. Only eighteen more were recognized before the year 1800 while fifty-two were found during the last century. Some sixty-seven of these are metals, four are active gases, seven, inert gases, one, a liquid and seven nonmetallic substances, leaving two as semimetallic and the balance to be determined.

A few of these elements are very common, the majority are very rare. Some are known by name, at least, to every one but it is doubtful if one person in a hundred in the United States can name the three commonest elements on earth. As a matter of fact, two elements form over 75 per cent of the atmosphere, the water and upper ten miles of the crust of the earth. Eight elements form over 97 per cent, thus leaving a very small balance to be supplied by all the rest.

Chemical Composition of the Earth's Crust and Atmosphere[3]

	Per Cent		*Per Cent*
Oxygen	50.02	Hydrogen	0.95
Silicon	25.80	Titanium	0.43
Aluminum	7.30	Chlorine	0.20
Iron	4.18	Carbon	0.18
Calcium	3.22	Phosphorus	0.11
Sodium	2.36	Sulphur	0.11
Potassium	2.28	Fluorine	0.10
Magnesium	2.08	Barium	0.08
		Manganese	0.08
	97.24	Nitrogen	0.03
		Strontium	0.02
		Nickel	0.02
		Copper	0.01
			2.32
		All others	.42

The proportion of these elements varies greatly in the different layers. Oxygen and silicon are in all silicates which form 59.8 per cent of the lithosphere. Hydrogen makes up 11 per cent of the hydrosphere and only 0.22 per cent of the lithosphere. Carbon is found chiefly in the carbonates, usually appearing as limestone.

It is evident that the above table ignores the make-up of the great central core of the earth of which we have little direct knowledge, since our deepest boring scarcely penetrates more than two miles below the surface. It is known that the mean specific gravity of the earth is about 5.4 or double the density of the lithosphere. Hence, the core must be much heavier and must weigh between 7 and 8. The probability is that the core is largely composed of iron whose specific gravity is 7.9.

> We must conclude that the center of the earth consists of metals, very probably molten and that iron is probably the chief component. This central mass makes up something more than half of the whole earth-mass. Over it there lies a lighter mass whose composition seems to correspond to that of igneous rock. In the deeper layers of this material prevail rock containing the heavier iron, magnesium and aluminium silicates, higher up come lighter silicates in which the iron and magnesium are replaced by the lighter metals, calcium, potassium and sodium, and uppermost lie layers richest in silica (quartz), which is the lightest of such rocks. Very probably all these silicates, save the uppermost, are in molten condition. This molten material corresponds to the magmas thrown out by volcanoes.[4]

In this process of earth creation, the heavier elements find their way to the center as the phenomenon of rotation would lead us to expect, while the uncombined gases form the atmosphere from which it is conceivable that some of the lightest occasionally make their way into the outer spaces and are lost to earth. The word atmosphere is in common use, but the equally valuable words hydrosphere (the water bodies) and lithosphere (the rock crust) are seldom heard.

The appearance and properties of many of these elements have been well known, but until very recently there has been little beyond surmise as to their nature and mutual relations. Long ago the Greeks, speculating as to the essence of matter, thought that it might be made up of minute particles which could not be further subdivided to which they gave the name of atoms. The word survived but the idea was lost for centuries. During the Middle Ages men sought in vain for some way to transmute the baser metals into gold. The atomic theory was revived by Boyle (1661) in his *Skeptical Chymist* and by the first of the nineteenth century received considerable attention from such men as the school-teacher Dalton, who devised our system of naming chemical compounds and who recognized that all atoms of any given element were alike. Meantime many new substances were discovered and studied. In 1774, Priestley and Scheele both found oxygen and the hoary idea that fire was a separate entity, phlogiston, was soon destroyed. Before 1800, Cavendish had discovered hydrogen and found that water was a combination of this with oxygen. A stream of discoveries followed and many new elements were revealed. In 1868, Johannsen of Paris, using a spectroscope, found an unknown element in the sun to which the name of helium was given. In 1895, Ramsay proved its presence on earth. Then came the epoch-making research of the Curies and the finding of radium in 1898.

Radium has revolutionized human thought or, more correctly perhaps, has given evidence for a long-dormant suspicion. It had long been known that matter would combine to form compounds but the elements seemed permanent and distinct, occupying space, but inert. Radium did not comply with these conditions. It did things regardless of the conditions man might impose upon it. It gave off rays of various sorts which were soon classified. The alpha rays proved to be positively electrified and to travel some

20,000 miles a second and to be stopped by a sheet of aluminum 1/500 of an inch thick. The beta rays are negatively electrified, travel 10,000 miles a second and are stopped by a sheet of aluminum 1/25 of an inch thick; while the gamma rays, apparently the same as X-rays, will pierce a plate of aluminum up to 20 inches or take a photograph through a foot of iron. We now know that what is happening is the break-up of the radium atom, after an average duration of two thousand years, regardless of external conditions, with the release of tremendous energy.

If the ninety-two elements are arranged in tabular form based on atomic weights, we have what is called the Periodic Table and some striking facts are revealed. The beginnings of such a table are given below. We start with the lightest element, hydrogen, as number 1 and find the following order:

Period I	2 Helium	3 Lithium	4 Beryllium	5 Boron	6 Carbon	7 Nitrogen	8 Oxygen	9 Fluorine
Period II	10 Neon	11 Sodium	12 Magnesium	13 Aluminum	14 Silicon	15 Phosphorus	16 Sulphur	17 Chlorine
Period III	18 Argon	19 Potassium	20 Calcium	21 Scandium	22 Titanium	23 Vanadium	24 Chromium	25 Manganese

The first thing to attract our attention is the fact that the elements fall into periodic groups and that substances occupying similar places in the different periods have very similar properties. Thus each period starts with an inert gas and if the entire table were given we should find that krypton, xenon, and niton headed the later periods. Such a coincidence is hardly accidental. It is known that the nucleus of each atom is charged with positive electricity and the number of charges corresponds to the number of electrons about the nucleus. Thus hydrogen has one electron and a nucleus with one charge, lithium has three electrons and three charges.

"Now it is reasonable to suppose that the properties of an atom as manifested by its relation to any other will be determined by some arrangement of its electrons and especially of those which are most on the surface and are first presented to the other atom. Thus, lithium, sodium and potassium, probably behave alike because they all have the same external presentment of electrons; and so with carbon and silicon, with fluorine and chlorine, and so on." [5] It appears that there is some definite arrangement of the electrons on the nucleus and that the most stable condition is when the outer shell consists of eight electrons. If one or two are lacking the atom seems to make effort to get them.

> It is, in fact, this power that Chlorine possesses of dragging to itself an electron from other atoms, and upsetting their combination in order to get it, which makes the substance so actively poisonous. In the same way, sulphur has two gaps to fill up, and its behavior is largely governed by that fact.[6] . . .
>
> Atoms may share electrons with one another, each being capable, apparently, of counting them in its own structure, just as two houses may have the same party wall. . . . In the diamond, . . . each atom is surrounded by four other carbon atoms, with each of which it shares two electrons. So each atom is provided with an external shell of eight electrons none of which it has entirely to itself. This kind of combination is generally very strong and molecules so formed hold together well.[7]

To this class then belong the inert gases.

Granted that the atoms of the different elements consist of a nucleus and its electrons arranged in some definite fashion, is there any evidence of relationship between the elements? The answer to this was found in the radioactive substances. The element having the greatest atomic weight and standing at the top of the natural scale is uranium 238.2. This is followed by thorium, actinium and radium. It has been learned that the beta ray given off by radium is the atom of helium. Moreover, Rutherford has been able to bombard electrically the nitrogen atom and secure the atoms of hydrogen. According to press reports early in 1926, scientists at Amsterdam by exposing lead to intense heat in high vacuum secured mercury and thallium and Taylor of Princeton by the collision of hydrogen molecules and mercury produced peroxide of hydrogen. There is good reason to believe that lead is a product of the disintegration of uranium. Thus we find both in nature and in the laboratory that a more complex atom can be reduced and give us substances already known to us as elements. Whether elements other than the radioactive ones are degenerating we have no idea, nor can we as yet do much to disrupt the atom, but a glimpse has been given us of its structure. On the basis of present knowledge it seems that the hydrogen ion, the nucleus of the hydrogen atom minus the accompanying electron, is the long-sought unit of positive electricity, the proton, which enters into the composition of all atoms. Shall we call it matter or electricity?

A few paragraphs ago our minds were being taxed to grasp the immensities of the interstellar spaces. At the other end of the scale of magnitude stand the atoms. So small are they that all ordinary measures fail us. Light cannot show details unless the objects are larger than the length of the rays. The X-rays are 10,000 times finer than light and so can reveal the atom. Let the reader see if he can visualize the diameter of the hydrogen atom, which is put at 1.1×10^{-8} centimeters, or that of uranium whose diameter is about two and one-half times greater.

Small, then, as are the atoms when they are packed together in some substance, there are still spaces between them as between the peas in a jar. "Even the diamond is full of holes like the sponge. If the holes were filled up by other carbon atoms the density of the diamond would be doubled, for each hole is just large enough to take one more carbon atom, and there are as many holes as atoms." [8]

Furthermore, it is believed that the electrons are in constant revolution so that from the greatest star to the hydrogen atom we find eternal motion.

It is evident that only under conditions of which we have little comprehension could the enormous forces have been exercised which have produced the integration of the more complex elements. But just such conditions must have existed, as we have noted, in the process of world formation, and may still exist, for all that we know, in the center of the earth where the pressure is enormous.

Matter is much more wonderful to us to-day than it seemed to our ancestors. We catch a glimpse of particles, minute beyond our power of comprehension, charged with electricity, drawn to each other at times, yet separated by the effects of constant motion.

> The atoms seem to cling to one another in some such way as two magnets do, when opposite poles are presented to each other; or two charges of electricity of opposite nature. In fact, there is no doubt that both magnetic and electric attractions are at work. . . .
>
> We may now ask why, if there are such forces, the atoms do not all join together into one solid mass? Why are there any gases or even liquids? How is it that there are any atoms at all which do not link up with their neighbors? What prevents the earth from falling into the sun and the final solidification of the entire universe?
>
> The earth does not fall into the sun because it is in motion around the sun, or, to be more correct, because the two bodies are moving around each other. It is motion that keeps them apart; and when we look closely into the matter we find that motion

> plays a part of first importance in all that we see, because it sets itself against the binding forces that would join atoms together in one lump. In a gas, motion has the upper hand; the atoms are moving so fast that they have no time to enter into any sort of a combination with each other: occasionally atom must meet atom and, so to speak, each holds out vain hands to the other, but the pace is too great and, in a moment, they are far away from each other again. Even in a liquid where there is more combination and atoms are in contact with each other all the time, the motion is so great that no junction is permanent.
>
> In a solid the relative importance of the attractive forces and the motion undergoes another change: the former now holds sway, so that the atoms and the molecules are locked in their places. Even in the solid, however, the atoms are never perfectly still; at the least they vibrate and quiver about average positions, just as the parts of an iron bridge quiver when a train goes over it. It is difficult to realize that the atoms and molecules of substances which appear to be perfectly at rest—the table, a piece of paper, the water in a glass—are all in motion. Yet many of the older philosophers grasped the fact.[9]

So writes Sir William Bragg in his remarkable book which cannot be too highly commended. An atom of hydrogen, oxygen, or nitrogen may unite with another of the same sort to form a gas almost as inert as helium or argon. Yet at extremely low temperatures hydrogen and oxygen as well as helium become liquids. In similar fashion mercury freezes to a solid. Every substance, then, has its freezing or melting points at which it changes form. At ordinary temperatures most elements are solids, but our life depends on the fact that some are gases and others liquids.

Hitherto we have spoken as if the elements were found separated in nature. Every one knows this condition to be the exception, not the rule. Our air is a mixture composed of 79 parts nitrogen, 21 of oxygen, about 0.03 per cent of carbon dioxide, and minute amounts of the inert gases, each 1,500 pounds of air containing about 18 pounds of argon for example. In addition it contains large amounts of water vapor as well as quantities of dust of various sorts. Pure air is a relative term as is pure water, for the latter scarcely exists outside of the laboratory. Chemically pure water contains two parts of hydrogen to one of oxygen but many salts as well as other impurities are found in ordinary water. In nature, then, we ordinarily find either mixtures, such as the air, or compounds in which the elements have united to form substances whose appearance and properties are widely different from those of the elements, such as water. Indeed, as a rule it is only with the greatest difficulty that we can secure any substance in strictly pure form. The reason for this has been suggested and does not further concern us but we shall encounter the fact on every hand. Thus, some 60 per cent of known inorganic compounds contain oxygen and 30 per cent hydrogen, while other elements, like gold, are rarely found in combinations. These compounds are quite as useful as the pure elements. In as much as the chemical combination of the elements depends in part on temperature and pressure, it is extremely fortunate that past conditions in the history of the earth have been such as to produce them.

The degree of chemical complexity capable of existing in the materials found on earth is definitely and sharply fixed by temperature. At a white heat such as exists in the sun's atmosphere, we have seen that only elements can exist, and many of these are decomposed into proto-elements. At a somewhat lower temperature binary compounds, such as the oxides, can remain in equilibrium, in incomplete combination, becoming more and more complete as the temperature falls, and as soon as their existence becomes possible these oxides do exist. Lower still in the scale of temperature, saline compounds, such as the chlorides of the alkalies, and mutually neutralized acidic and basic oxides combined together, can stand the heat. Such bodies as the carbonates of calcium and magnesium can now be present in an incomplete state of combination, partially as oxide and partially as carbonate, in labile balance as the temperature fluctuates up or down, and the pressure of carbon dioxide in the atmosphere changes. Whenever the environmental conditions make their presence possible, these more complex forms must promptly make their appearance by chemical law.

But it is only at a very much lower temperature that compounds at all complicated in chemical structure can exist in equilibrium, and for those compounds of many hundreds of atoms, which are characteristic of life, the range is narrowly limited.

This note cannot be too strongly sounded that as matter is allowed capacity for assuming complex forms those complex forms appear. As soon as oxides can be, there oxides appear; when temperature admits of carbonates, then carbonates are forthwith formed. These are experiments which any chemist can to-day repeat in a crucible.

It may then be summed up as a general law universal in its application to all matter, although varying in its intensity in different types of matter, and holding throughout all space as generally as the law of gravitation—a law which might be called the Law of Complexity—that matter so far as its energy environment will permit—tends to assume more and more complex forms in labile equilibrium.[10]

The application of this suggestion to life itself will be considered in the following chapter. That which needs to be noted here is that the development of the world itself has prepared the basis for the continued existence of all organisms and has put in the air or on the surface of the earth the necessary elements, as well as compounds.

More and more it becomes clear that the old idea of creation as a past event gives an inadequate picture of the facts. In so far as we can tell, creation is a process going on in the world about us as much to-day as ever. Water and air are not only modifying the surface of the earth but are being modified themselves.

Geological History of the Earth

If, as we have abundant evidence for believing, the surface of the earth was once molten, the atmosphere must have contained an enormous amount of water vapor as compared with to-day, for water could not rest on the melted earth, if, indeed, the heat allowed the hydrogen and oxygen to remain in combination. The atmosphere in this early period must have been rich in carbon dioxide and poor in oxygen. When living organisms appeared, the carbon dioxide was gradually removed from the air and the oxygen taken from the rocks was given to the air until the present mixture was secured.

On the moon gravity is so much less, because the moon has only 1/80.5 the mass of the earth, that all of our common atmospheric gases, as well as carbon dioxide and water vapor, long ago escaped. This is why the moon is dead. So much for the influence of size and mass. But if the moon's atmosphere had always been exceedingly cold, as cold as it would have been if lying as far from the sun as Neptune, probably carbon dioxide, water, oxygen and nitrogen would still be retained, because the molecules would not go fast enough to defy gravity to hold them. So much for temperature influence on the composition of the atmosphere.[11]

Mars presents an almost unclouded appearance to our eyes, despite the faith of Pickering in the existence of "canals," whereas the earth viewed from Mars would be cloudy a good part of the time. In earlier ages the clouds would have been much heavier. Our water and air are due, then, to the size of the earth as well as to earlier conditions of temperature. It is interesting to ask ourselves whether the amount of water is increasing or decreasing on earth and whether under existing conditions hydrogen and oxygen are being combined to form new supplies. Perchance, instead, the lightning is disrupting the water molecules and setting the gases free.

The winds are changing the face of the earth more than is generally realized. The creeping sand dunes may destroy vegetation over wide areas or block the streams and thus injure man or, in other cases, help him by building up a barrier against the waves. An enormous amount of airborne dust is distributed over wide areas to form the loess soils of China or eastern Washington. Amethyst Mountain in Yellowstone Park shows at least seventeen forests, one above the other buried in volcanic dust. The sand particles carried by the wind are carving the cliffs into fantastic forms.

The distribution of the land and water areas presents some interesting problems. The present positions of the oceans and continents have been more or less permanent throughout all the time which geologists can measure. Yet there is evidence that shallow seas were once far more numerous than to-day. It is known that the specific gravity of the earth beneath the oceans is much greater than that of the continents. Barrell believes

> that the ocean basins have been formed by the subsidence of broad areas of the crust, owing to the weight of magmas of high specific gravity rising widely and in enormous volume from a deep core of greater density into those portions of an originally lighter crust. This regional subsidence was especially characteristic of primordial times, but the process did not wholly cease then; since certain lines of evidence suggest that some ocean basins have been extended in later geologic ages, breaking into once wider continental platforms. The resultant increase in the volume of the ocean basins has led to a drawing off of the ocean waters from the continental areas, and a marked diminution of the shallow seas of earlier ages.[12]

That the weight of the lava (magma) accumulating on a given area may be "enormous" may be seen by glancing at the vast lava field, covering between 200,000 and 300,000 square miles in Washington, California, Idaho, and Oregon, which is over 5,000 feet thick, having been put down in layers averaging about 75 feet.

It is well known that many of our mountain ranges were once seashores. I have seen clam shells on some of the mountains of Haiti as thickly packed together as on any beach. The shrinking of the earth, together with the deposition of enormous weights of magma, seems to have produced from time to time those titanic convulsions which have thrown up the mountain ranges. The difference in the elevation of the earth's surface starts the waters flowing and causes the phenomena of erosion.

From the foot of the glacier comes a milky stream colored by sediment from the rocks ground to powder by the ice. From the hills the streams are carrying vast quantities of dirt to be deposited in the lowlands or carried to the ocean. Thus the Mississippi has built a delta of over 60,000 square miles extending practically from its old mouth at Cairo, Illinois to the Gulf where it is now depositing some 113,000,000 tons of silt yearly and extending its delta at the rate of a mile in sixteen years. This delta is so thick that driftwood has been found in a boring 1,042 feet deep at New Orleans. The entire land surface of the United States is being lowered at the rate of an inch in 760 years. All over the earth the same thing is happening. Slow as the rate may seem, the total amount carried to sea from the United States yearly is 270,000,000 tons of dissolved matter and 513,000,000 in suspension. Between one and two miles of igneous rock have been eroded from the surface of the earth, more than half of this having taken place before the Paleozoic era. The Rhone River has added a mile to its delta since Roman times. The town of Pu-tai in China, said to have been a third of a mile from the sea in the year 220 B.C., is now 48 miles from the shore. Some ocean shores are sinking, others rising. Erosion has taken some 3.5 miles from the top of the Uintah Mountains in Utah. Earthquake and volcano show that the earth is far from finished. "Even though the earth has been dissipating its inherited and derived energy for at least some hundred millions of years, and in so doing repeatedly given birth to a new series of mountains, our mundane sphere is still far from having attained that internal stability that will, when achieved, result in a featureless earth, an atmosphere devoid of the carbon dioxide that is the basis of life, and a universal lifeless ocean—the facial expression which the earth will have in its old age." [13]

Originally all the water on earth was fresh; now, as every one knows, the oceans and some lakes are salt. Throughout the ages the waters have been dissolving various salts out of the earth and carrying them to the oceans. Some of these have been deposited in great beds to be the supply of present generations, like that of Stassfurt in Germany which is 4,794 feet thick. Enormous deposits are reported from the Dead Sea of Palestine. Salty as the water of the ocean seems, it contains only 2.7 pounds per hundredweight. To have taken this amount of salt from the land and transferred it to the ocean has required from one to two hundred million years. Great Salt Lake in Utah is but the salty remnant of the vast fresh-water Lake Bonneville whose waters once flowed north through the Bear River, which now empties into the lake, and the Snake to the Pacific. This lake now contains 18 per cent of salt and a person cannot sink in it. Other lakes in arid regions have deposited most of the common salt (NaCl) and the liquid remaining is chiefly Epsom and Glauber salts. A similar fate awaits the oceans.

In the table of the chemical elements on page 8 no mention was made of such valuable substances as gold, silver, and platinum, while the much commoner metal copper appears at the foot of the list. Relatively they are very scarce, yet, as every one knows, they are sometimes found in considerable amounts. How does it happen? The explanation seems to be that they have been deposited in favored spots by the waters which constantly circulate in the earth. Water is a splendid solvent, assisted at times by other substances. There is a circulation of the water in the soil comparable to the circulation of the air. No one knows how deeply into the earth it penetrates. Coming in contact with all the different elements, it has collected them and deposited them, possibly bringing many of them nearer the surface. Add to this the subsequent elevation of the mountain ranges and the later erosion by ice and water and we get a glimpse of the process. This explains the presence of minute quantities of gold in the oceans as well.

> It may be broadly stated that were it not for the circulation of water with vast depths of the earth's crust we would have no workable deposits of any of the metals such as iron, copper, lead, tin, chromium, gold, platinum, or even of lime, phosphates, or petroleum. These materials with the exception of petroleum were originally contained in the molten magma of the earth and in the igneous rocks resulting from the cooling of the same. Most of them are present in only small proportions and are only very slightly soluble in water. For instance lead is contained in igneous rocks to the extent of .004 per cent, zinc .009 per cent, and copper .006 per cent. They are present in ordinary soil to about the same extent. Through various processes of chemical solutions and reactions and differences in solubilities of the various compounds they form, these metals have been completely separated from each other, carried up to or near the surface of the earth where, under other conditions, of which we know little or nothing, they have been deposited in workable beds often of immense proportions at different places on the earth's surface At other points on the earth's surface conditions are unfavorable for their precipitation and they wander up and down with the circulating waters in an unending search for a resting place. What a vast amount of water must have been used for their transportation to the surface and how complex must the process of separation and final segregation have been.[14]

This process produces results both good and bad from the standpoint of man. The leaching of soluble salts from the ground in countries of good rainfall would mean that in time the elements necessary for plant food would be carried away and the land rendered sterile. Of the 272 pounds mentioned above as taken from each acre about 5.79 are potash and 0.54 pounds phosphoric acid. Yet there is abundant evidence that many old soils are fertile. The only answer must be that new supplies are brought in by the earth water. This is fortunate for man. In countries of poor rainfall many salts distinctly injurious to plant growth —calcium, magnesium, sodium—are brought to the surface and deposited as alkalies. There is plenty of evidence of this in the territory between the Rocky Mountains and the Sierras.

Let us restate briefly what is now known of the earth.

> Taking all known facts into consideration . . . the best opinion is that the earth has a skin of ordinary earth and rock about 60 kilometers (37 miles) thick, then a shell 1,600 kilometers (954 miles) thick of compounds of iron, magnesium, and silicon, then a shell 1,400 kilometers (37 miles) thick in which iron begins to predominate, and finally a nickel-iron core something like a meteorite in make-up 6,800 kilometers (4,225 miles) in diameter. The pressure at the center is something like 50,000,000 pounds per square inch, and the material there is about 10 times as heavy as water. Of course, other substances like platinum, gold, silver, lead, copper, are scattered through the mass, but it is not supposed that they make up a very large portion of the central core as compared to nickel-iron. This view is taken partly on account of the well known composition of meteorites.

So much for the size, weight and structure of the earth. Now a few words about its indispensable coverings, air and water. About 70 per cent of the earth's surface is submerged in water, and to an average depth of 12,000 feet. The atmosphere stretches up and up, getting rarer and rarer, till at 15 miles above the earth's surface 24/25 of it are left below. Yet there is air sufficient to produce white heat in meteors, as they rush into it, as high up as 100 miles. At the earth's equator, the air is composed in percentage by volume roughly as follows:

	Nitrogen	*Oxygen*	*Carbonic Acid*	*Water Vapor*	*Argon*	*Other Gases*
Per Cent:	76.0	20.04	0.02	2.6	0.9	0.01

The water vapor load varies from 0.1 per cent to 4 per cent of the weight of the permanent gases in different times and locations. At higher elevations, water vapor rapidly grows less. Carbonic acid also diminishes, but not so fast. It is supposed that at very high levels the composition of the atmosphere is utterly changed. Ozone (another form of oxygen) is there as the spectroscope shows us, and it is supposed that finally helium (that light gas first found in the sun and now used to fill balloons) and other light gases predominate.[15]

Our evidence, then, indicates that the surface of the earth cooled first into igneous rocks. These were worked upon by ice, water, and air, and broken down into particles which were either deposited in place or carried into new locations. Thus arose under pressure the sedimentary, stratified rocks whose total depth is somewhere in the neighborhood of 80 miles. In turn these are eroded to form new layers, or to serve as the soil. Not all of these layers of stratified rocks are found in any one place. It is impossible to compare the age of the igneous rocks of different parts of earth but such a comparison can be made of the stratified in large measure because of the fossils they contain. We must not forget that both igneous and sedimentary rocks have often been changed under the influence of heat and pressure into metamorphic rocks which because of volcanic activity may now be found on the surface of the earth. Thus, the Palisades of the Hudson are of lava superimposed on sandstone.

The stratified rocks are of three main classes:

1. Limestones, made of carbonates of calcium and magnesium
2. Sandstones and conglomerates, whose character varies with their composition
3. Shales which are consolidated mud

Regions underlain by shale are usually low and flat like the "Black Belt" of Alabama and the Mohawk Valley. The metamorphic rocks resulting from the above are as follows:

the limestone is turned into marble, sandstone turns into quartzite and shale into schist. The transformation of bituminous coal into anthracite may be mentioned also.

In as much as the soils are either formed in place by the decay of rocks, or else their particles have been moved to new locations by ice, water, or wind, we may classify them as:

Sedentary: 1. Residual gravels, clays sands
2. Peat, muck, swamp soils
Transported: 1. Alluvial
2. Glacial
3. Wind-blown, sand dunes, loess

Soils of these different types will have widely varying characters both as regards structure and chemical content. The particles of which they are composed will vary in size from the dust which forms clay to coarse gravel. Disregarding their water content they range in weight from peat at 40 pounds per cubic foot, through clay at 75, half sand and half clay at 96, to silicious sand at 110. The texture of the soil is determined by the arrangement of its particles which in turn determines the moisture it may hold. In fine clay the pore space is about 50 per cent but in coarse sand it is only 25 per cent. The importance of the relation of the soil to crops is now recognized and most of the soils of the country have been carefully studied as well as named.

In as much as the geologist measures time by eras rather than by years this appears to be the most logical place for the table showing the various eras, although hitherto any consideration of living organisms has been avoided.

The Geological Time-table

Present Time

Psychozoic Era. Age of Man or Age of Reason

Includes the present or "recent time" and the time during which man attained his highest civilization, estimated to be probably less than 30,000 years

GEOLOGIC TIME

- *Cenozoic Era.* Age of Mammalian Dominance
  - Glacial or Pleistocene time: last great ice age
  - Late Cenozoic or Pliocene and Miocene time: transformation of apes into man
  - Early Cenozoic or Oligocene and Miocene time: rise of higher mammals

- *Mesozoic Era.* Age of Reptilian Dominance
  - Cretaceous period: rise of archaic or primitive mammals
  - Comanchian period: rise of flowering plants and higher insects
  - Jurassic period: rise of birds and flying reptiles
  - Triassic period: rise of dinosaurs

- *Paleozoic Era.* Age of Fish Dominance.
  - Permian period: rise of reptiles; another great ice age
  - Pennsylvanian period: rise of insects and first time of marked coal accumulation
  - Mississippian period: rise of marine fishes
  - Devonian period: first known amphibians
  - Silurian period: first known land floras
  - Ordovician period: first known fresh water fishes
  - Cambrian period: first abundance of marine animals and dominance of trilobites

- *Proterozoic Era.* Age of Invertebrate Dominance
  - An early and a late ice age.

- *Archeozoic Era.*
  - Origin of protoplasm and simplest life.

COSMIC TIME

- *Formative Era.*
  - Birth and growth of the earth out of the spiral nebula of the sun. Beginnings of the atmosphere and hydrosphere, and of continental platforms and oceanic basins; no known geological record[16]

The following tables will give some idea of the relative length of the different eras.

TABLE OF SEDIMENTARY ACCUMULATION IN NORTH AMERICA[17]

Eras	Thickness and Nature of Deposits	Probable Era Ratios
Cenozoic	5 miles of coarse detritals	5
Mesozoic	6.25 miles mud-sands 1.25 miles limestones	12
Paleozoic	4.6 miles mud-sands 3.4 miles limestones	28
Proterozoic	13 miles coarse detritals 1 mile limestone	15
Archeozoic	9 miles mud-sands 9 miles limestones	40

In 1917, Schuchert and Barrell estimated the geologic time ratios as indicated below.[18]

Eras	Schuchert, Per Cent	Barrell (Based on Uranium), Per Cent
Cenozoic	5	4
Mesozoic	12	11
Paleozoic	28	30
Proterozoic	30	55
Archeozoic	25	..

To complete this brief summary of the facts of the inorganic world we must glance for a moment at some of the phenomena of motion which is quite as characteristic of matter as is mass. For long ages man had perceived through his various senses some of these movements and had classified them under such titles as sound, heat, electricity, light. We do not need to survey the earlier attempts to understand these phenomena but it is well to recall that a century ago heat was thought of as a *fluid*. With the discovery that atoms and their electrons and ions were moving as well as molecules and masses, the way was opened for better understanding. A few atoms are breaking up in nature. Man can disrupt a few. He has a notion that if he knew more he could have a source of power beyond anything he now knows. That may or may not be true. It marks a great advance that he has learned something of the richness of nature and of the poverty of man. He hears sounds produced by vibration of molecules up to a certain limit when his ears cease to function. Insects appear to be better equipped. Man feels the atomic vibrations known as heat. He sees as colors some of the vibrations of electrons but far beyond the range of his vision are other rays. The waves of the wireless telegraph and radio are long—sometimes 15 miles from crest to crest. Passing the relatively short Roentgen and gamma rays, we reach the limit of present knowledge in the very short "cosmic" rays of Milliken. Substances opaque to the rays of light are easily penetrated by the short rays. To perceive these short rays we have to step them down to the range of our senses. Already we have learned to utilize many of them.

Matter, then, is not the dead, inert thing of which we used to talk. The sharp line man used to draw between matter and life becomes a hazy boundary belt separating two classes of natural phenomena which are, perhaps, as closely related as heat and light. The world becomes more marvelous, not less, and man stands in greater awe before its mysteries.

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12. J. Barrell in Lull, *op. cit.*, p. 39.
13. C. Schuchert in Lull, *op. cit.*, p. 48.
14. M. Whitney, *Soil and Civilization*, pp. 43-44.
15. C. G. Abbott, *op. cit.*, pp. 51, 52.
16. C. Schuchert in Lull, *op. cit.*, pp. 47, 48.
17. *Ibid.*, p. 67.
18. *Ibid.*, p, 69.

CHAPTER II

LIFE, ITS NATURE AND DISTRIBUTION

> The search for truth is in one way hard and in another easy. For it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of nature, and from all the facts assembled there arises a certain grandeur.
>
> —ARISTOTLE.

The atoms of most of the elements do not lead an isolated existence but combine to form molecules. In a few substances such as mercury this does not happen, and atom and molecule are synonymous terms. We say that they are drawn together by the power of chemical affinity but, as is so often the case, that is a term rather than an explanation. The atoms of different elements may join to form molecules of a new substance. Most of these inorganic compounds are simple. When, however, we come to the organic molecules we find hundreds or even thousands of atoms uniting. This increased complexity attracts our attention. At once the question rises in our minds as to when, where, and how, such a combination into living forms took place. To this question no positive answer can be given. In the past men felt compelled to posit the existence of some "vital principle" which, in some way, entered into matter and gave it life. Again we have a term and not an explanation. In reality we do not understand matter. We cannot visualize its creation any more than its destruction. What we can do, if we are fortunate, is to observe what matter does and under what conditions. The same holds true of life.

ORGANIC COMPOUNDS

At the outset let us notice that the difference between inorganic and organic things does not lie in the elements of which they are made, although only a few of them are known to be used in organisms. Those which have been found are hydrogen, oxygen, nitrogen, fluorine, iodine, chlorine, iron, magnesium, sodium, potassium, manganese, lithium (?), phosphorus, sulphur, and carbon. All of these are ordinarily substances and the market value of the materials of which a man's body is made is perhaps ninety-eight cents.

The terms which we have used—organic and inorganic—give the clew to the answer. Living beings have a different organization and behave in a different way. There is no evidence that any new material has been used. In view of this fact we have to assume that at some time in the history of the world the conditions were such that matter assumed organic form and life began, just as we have seen that water vapor formed when conditions were favorable. What these conditions were that favored life we do not know. There is no evidence that matter has assumed organic form at any time within the knowledge of man in spite of his hoary faith in spontaneous generation. This is, however, a confession of ignorance, not a statement of fact. No organism known to man can live and reproduce at the temperature of boiling water (212°) nor below the freezing point (32°). Life then could not have existed until the surface of the earth had cooled below the boiling point. All that we know is that when conditions were favorable life appeared. Moore would have us believe that this was due to a "law of complexity" and since he accepted the nebular hypothesis, he would have located the Garden of Eden near the poles of the earth, probably, as the place where the necessary temperature would have first existed. If, however, the planetary hypothesis is accepted, the climate may have been substantially the same over all the earth for long periods. We have, then, no idea where or when life appeared although we may establish certain limits. If we look about us to-day we observe that wherever life is possible, there life is, and we may be justified in holding that the same must have been true at all time. We may be justified also in holding that life first appeared in the water or in moist earth, for the simplest types we know exist under such conditions.

Primitive Protoplasm

Even if we assume that matter takes an organic form under certain conditions, we have no idea of the characteristics of this original protoplasm. The colloids have large molecules but the colloid is far from being an organism. On the other hand the lowest organisms we know are far too complicated to have been the first living products of nature. Probably we shall have to say with Moore that "the territory of this spontaneous generation of life lies not at the level of bacteria, or animalculæ, springing forth into life in dead organic matter, but at a level of life lying deeper than anything the microscope can reveal, and possessing a lower unit than the living cell, as we form our concept of it from the tissues of higher animals and plants."[1] Moore touches here on a point that should not be forgotten. Just as there are bits of matter too small to be seen so there are living organisms beyond our vision to-day which some day man may be able to study.

The initial organisms were probably like bacteria, the first organic form capable of the capture of energy and its storage. As Osborn says, bacteria appear to lie halfway between our hypothetical chemical precellular stages and the chemistry and definite cell structure of the lowliest plants or algæ. These creatures are often known more by the chemical and other reactions which they bring about than by their form. . . . All of them, however, from the smallest to the largest, while among the simplest of organisms, are nevertheless highly complex. Next in the scale of life come the algæ, distinguished by the possession not alone of protoplasm, but of leaf green, or chlorophyl, as well. Which is the older substance it is difficult to decide. Certain authorities claim that it is chlorophyl, without which protoplasm cannot be manufactured in the living organism. For the chlorophyl in the presence of light has the power of utilizing carbon dioxide and water and manufacturing starch. Protein formation comes next and needs as raw materials not only the already made starches, but certain nitrogenous compounds, which are derivable from animal waste or decay, but can also be made by certain nitrogen-fixing bacteria. The animal can make neither starches nor proteins, but must take them ready made from the plant.[2] . . .

There is one compound or group of compounds which is absolutely diagnostic of life stuff in that the substances are never found under any circumstances other than in the bodies of organisms, living or dead. These are the proteins, composed of carbon, hydrogen, oxygen, and nitrogen, with traces of other elements, such as sulphur. The molecules of protein are so complex that their atoms, instead of being numbered by the twos or threes, as in so many chemical substances, are actually in the thousands. Protein is an absolutely essential constituent of protoplasm, which in its turn is the primary building material of all organisms of whatever sort, whether plant or animal. Other organic compounds, in addition to the proteins, are the fats and oils, and the starches and sugars. None of these substances occurs in nature except as an organic product. There are, in addition, several other materials, such as water, common salt, and the various skeleton- or shell-forming substances, containing lime or silica.[3] . . .

Physically, protoplasm is a viscous, semi-fluid mass of matter, often appearing granular beneath the microscope, again emulsoid in structure. Its color is grayish pellucid, the color of clear glass or of water.[4] . . .

Physiologically, it possesses properties which are distinctively vital, as compared with the inertness of the inorganic, such as sensitivity, conductivity, and irritability, whereby stimuli are received, transmitted, and responded to throughout the cell, for the cell is the unit of structure in the form of which protoplasm invariably appears.[5]

We must not think of protoplasm as a fixed compound: there are different protoplasms. Plants are composed largely of oxygen, hydrogen, and carbon. The human body contains: carbon 13.5 per cent, hydrogen 9.1 per cent, oxygen 72 per cent, nitrogen 2.5 per cent, calcium 1.3 per cent, phosphorus 1.15 per cent, sodium 01. per cent, iron 0.01 per cent, magnesium 0.001 per cent, and traces of silicon and fluorine. Although the structural materials are similar the results are very different. That which should be emphasized here is that organisms are made up of cells which consist of matter arranged in certain ways and that the phrase "vital principle" is but the term applied to the behavior of matter so arranged.

Temperature of Organisms

Now that we have had a glimpse of the structure of organisms let us consider some of the conditions under which they function. It has been suggested that organic compounds are sensitive and subject to change. These changes are largely chemical in nature and such changes depend much on temperature. The maintenance of a fairly stable temperature would seem, then, to be necessary. It cannot be an accident that the various types of life have characteristic temperatures at which they prosper. Some bacteria will live and multiply in water at a temperature of 32° while other sorts flourish in hot springs where the thermometer registers 170°. The human body has a normal temperature of 98.5°, being lower at night and lowest in the early morning. If attacked by fever the temperature rises, and if it reaches 105° we know that the patient is in a dangerous condition and the same is true if the temperature falls to 93°. Changes in bodily temperature probably produce new chemical compounds. We perish from cold long before the body is actually frozen. Physical exercise raises the temperature about one degree and we begin to perspire. This reduces the amount of water in our bodies and we get thirsty. We find it harder to keep cool than to keep warm for if we are cool we put on clothes or exercise and go about our business. Our clothing is a better conductor of heat than is the air but is valuable because it keeps a layer of air about the body. In order to keep our bodily temperature fairly even we burn (oxidize) a large part of the fats and carbohydrates that we eat. By weight, some 68 per cent of the body is water. An adult weighing 168 pounds produces while at rest some 2,400 calories (heat units) daily, or sufficient to raise the body temperature 57°. Since this does not take place he must lose about 1.5 calories per kilo per hour. If we could substitute most other substances that we know for the water, the heat produced would raise the temperature from 180° to 270°. Thus in our bodies, as well as in our houses, we find that water gives the most even temperature.

Properties of Water

Of all known substances water is the best fitted for the service just mentioned and it is the only one existing in adequate quantity. Its specific heat is very high, being exceeded only by hydrogen and ammonia, and if atomic weight be considered also, it stands at the top of the list. The freezing point of water is about 100° higher than that of most substances. This means that the latent heat of water is very high, being surpassed by ammonia only. Since water expands when it changes to ice, the actual freezing of more than the surface of a body of water is practically impossible. Water evaporates readily. At the equator some 6½ feet of water are taken yearly from the surface of the ocean. This spreads over the earth and prevents the rapid dissipation of the heat received from the sun during the day, not only modifying the temperature of the different zones but bringing rain to regions otherwise arid. Ammonia might rival it in these regards but ammonia is nowhere common and it has other qualities which are less desirable. Water is a splendid solvent and thus makes possible many of the combinations needed by organisms. Its surface tension (75) is exceeded only by that of mercury (436) and as a result its capillary action enables it to penetrate the recesses of the earth as indicated in the preceding chapter and to find its way into the cells of plants and animals. Taking all of these things into consideration it is evident that life as we know it is absolutely dependent on water.

Carbon and Its Compounds

Wherever there is life there is carbon, and organic chemistry might be called the science of carbon compounds. Of these over a hundred thousand are known. Many of them are simple, like carbonic acid; others are so complex that a line would be required to write the formula. This element is peculiar in that it has the power of uniting with itself, as well as with other substances, and thus is able to build up the large molecules containing a great number of atoms which characterize living structures. Moreover, such carbon molecules are relatively stable and thus give a needed permanency to delicate organic substances. "It is a curious fact in nature that there seems to be a position of great stability when groups of six carbon atoms unite in little galaxies or concatenations. . . . Although such groups of less, or occasionally more, than six carbon atoms are formed naturally by life processes, by far the greater portion of the substance of living organisms is built up of six carbon groups and multiples of them."[6]

Carbonic acid enters and leaves water freely and is always associated with it. From the first "it has steadily fulfilled the function of regulating the reaction of protoplasm and of body tissue and fluids. The one chemical process which is open if any transformations whatsoever are to be accomplished with carbonic acid and water leads directly and to all appearances to the greatest complexity that has been found in any one chemical process; to a system made up of possibly two hundred substances or more, most of which possess very great chemical activity." [7]

Carbon forms an important part of most of our foodstuffs. In the sugars and starches (carbohydrates) there are thirty or forty of these great carbon groups joined together. The fats are formed by the substitution of hydrogen for part of the oxygen contained in the carbohydrates while in the proteins we find nitrogen and, sometimes, phosphorus, sulphur and iron. Let us see what happens in the human body. Haldane found that the respiratory sacs of the lungs always contained 5.5 volumes of carbon dioxide to every one hundred volumes of air.

> He observed that if the proportion of CO_2 becomes higher then the breathing is quickened, thus washing out more CO_2 from the respiratory chambers and replacing it with air. If the proportion becomes less than normal, then the breathing is slowed until the usual proportion is restored. . . . Not only are the respiratory nerve centers disturbed by an excess of CO_2 in the blood supplied to them; they are also thrown into an equally excitable state if there should be a deficiency of oxygen. The rate of our breathing is automatically controlled by the percentage of oxygen and carbon dioxide in the arterial blood—the two substances connected with combustion.[8]

Oxygen enters the scene with its "unparalleled instability." "The body at rest requires this constant supply of oxygen—250 c.c. per minute—to supply the heart (its muscular blood-pump), the muscles of respiration (which work its air-pump), and other muscular engines, such as stomach and bowels, with the means of burning and restoring the lactic acid which each of them is continually forming."[9] The blood gets its oxygen in the lungs. This is carried through the body to do its regenerative work and the carbon is carried back to be thrown out through the lungs. In violent exercise the oxygen supply must be greatly increased.

ORGANISMS AS CHEMICAL ENGINES

An organism, then, is a chemical engine made up of a multitude of parts, each having its own function and the welfare of the whole depending on the coördinated functioning of each part. The food must be transformed by that process which we call digestion into bone and muscle or burned to produce heat. Limiting our illustrations to the human body, we know that nature has achieved a wonderful correlation. Gradually man has come to understand how the body works though many things still puzzle him. Our everyday language still carries hints of long-discarded interpretations as, for instance, when we say that a man has melancholia (black bile) or that he is hard-hearted. Only yesterday we learned the importance of the ductless glands hitherto considered of little importance. The suprarenals, two glands not over an ounce in weight, secrete adrenalin which stimulates the arteries in times of emergency and stimulates the liver to release its supply of fuel (sugar) into the blood. The thyroid gland makes the tissues sensitive and "greedy for oxygen," while their failure produces the cretin. The little pituitary gland at the base of the brain controls body growth and, if overdeveloped, causes giantism. The sex glands are responsible for the traits peculiar to each sex. If the body is to maintain an upright position there must be a bony framework strong enough to support the weight and yet to be flexible. Fortunately nature has discovered in lime a material that will work and remain substantially permanent. Through the lens of the eye the sunlight is focused on the retinal rod and a picture is formed, just as in a camera, to be recorded in some mysterious way in memory. Here nature needed material which changed with the rapidity of light and which possessed qualities quite the contrary to bone. In order that there may be permanency of the body, some parts must be substantially fixed and permanent while elsewhere the body is fitted to give instant and appropriate response to new conditions and stimuli. Varied as these demands are, nature is able to meet them out of the few elements that man finds on the surface of the earth. We are all familiar with the old illustration of the lily beautiful *in spite* of the mud in which it grew. It now seems that the lily is beautiful *because* of the mud. Did not these inorganic substances possess their peculiar properties, life could not be.

Strong as this last statement is, it does not tell the whole story. Nature has not only used common materials in the making of organisms but has used the only ones possessing the necessary qualities in so far as man knows. No wonder that Henderson writes of the "fitness of the environment" and emphasizes the reciprocal character of the relationship between physical environment and organisms. Man has long known that organisms not only existed but made things which he could not reproduce and which were never found in nature apart from organisms. He had no choice but to conclude that life must be something quite distinct from matter, and so there was a great gulf between inorganic and organic chemistry. This gulf was bridged in 1828 when Woehler succeeded in producing urea from ammonium cyanate. To-day the chemist can produce synthetically dozens of organic compounds and we see that organisms but furnish the environment under which certain chemical combinations may take place. Life itself remains as much of a mystery as ever even though man interprets it in terms of chemistry rather than "vital principles." Man can make organic compounds but he cannot take the materials and make a living cell.

The organism has been compared to a machine but it differs from any machine in that it not only functions and repairs itself but reproduces itself. We find no counterpart to this in the inorganic world. The life of a given organism, whether it be a single cell or a human being, is measured in terms of a few hours or years, but the existence of a species may have to be measured in eras, generation succeeding generation: the individuals comprising each generation almost identical with those of the distant past. Nature furnishes the environment and determines the conditions under which each type of life may live and reproduce and to these conditions the organism must be adopted. The terms "control of the environment" and "adaptation" merely indicate the two viewpoints from which the process may be studied.

Physical Environment of Organisms

The relation of the physical environment to organisms may be considered under two heads, topography and climate. It should not be forgotten that, here as everywhere else, hard and fast boundaries do not exist in nature but are created by man for convenience of discussion, and that in reality there are endless interrelations.

Topography

Altitude, the distance below or above sea level, is of importance because of its connection with the composition of air and water and their pressure on the bodies of organisms. It affects temperature and sunlight. At an elevation of 18,000 feet, the air pressure is only half of that at the sea level. If we make an ascent in an airplane we encounter new experiences. "Very likely our respiratory system will fail us, unless we be among the fortunate ones with a highly adaptable mode of breathing. If we are observant we shall notice as we reach a height of 12,000 feet or 14,000 feet, that our hearing becomes less acute, our sight somewhat blurred, and our mental perception sluggish. We may become emotional and be moved to laughter or to tears. A headache comes on and a sense of lassitude creeps over our bodies; the condition known as 'mountain sickness' develops. . . . It is worth making such an ascent were it only to learn how much clear thinking depends on an ample supply of oxygen to the nerve cells of the brain." [10] What happens is that in the effort to get the necessary air the breathing is increased, causing a decrease of the residual carbon of the lungs. People with heart trouble find altitudes over 5,000 feet dangerous. In time readaptation may come with an increase of perhaps 50 per cent in the number of red blood corpuscles. The development of flying during the war showed the necessity for the careful testing of aviators as to their physical fitness for high altitudes and their powers of readjustment. Mount Everest remains unscaled though two men lost their lives within a thousand feet of the summit. Younghusband's account of the British expedition to Tibet is amusing as well as interesting in its portrayal of the actions of men accustomed to lower levels.

An increase of pressure produces effects just as marked. During the construction of the tunnels under the Hudson one physician treated some 2,400 cases of caisson disease, popularly known as the "bends." It is considered a great feat for a submarine to go to a depth of over 200 feet and return to the surface. Few of the surface fishes could stand the water pressure at any great depth. Whatever the reason, and absence of oxygen may be a factor, there seems to be less life in the oceans below the upper few hundred feet than anywhere else on earth.

The uneven elevation of parts of the earth as illustrated by mountain ranges or oceans not only creates our scenery but has profound effects on climate which will be noted later. It causes also the slopes on the land resulting in very unequal exposure to the rays of the sun and to the force of the winds. Thus topography is one of the great casual factors in climate just as present topography is in considerable part the result of earlier climates. As indicated in the first chapter, the topography of the earth is constantly changing and with this change come changes in climate which have had marked effect on the distribution of life on earth.

Climate

As every one knows, the sun is our chief source of light, heat, and energy. The rotation of the earth on its axis produces the phenomena of day and night, the two being substantially equal at the equator and the poles but varying widely in the temperate zones. This results in the alternation of the seasons in the northern and southern hemispheres. The different response of land and water surfaces to the heat of the sun creates the two climates which we call marine and continental. Seasonal changes are much less marked on the ocean than on land.

The extremes of temperature are much greater on continental areas. Here the maximum temperature is attained about one month after the sun reaches its highest altitude; the minimum about one month after its lowest declination. In marine areas the maximum temperature comes a month or so later (August), while the minimum is not reached before March. In the interior of the United States, the temperature of the winter months fluctuates more than 4.5° about the mean and in Russia 6.3°; but in the coast climate of England only 2.7°. The ocean climate changes less from day to day and the extremes are less. The temperature in large bodies of water varies to some extent with the depth, though it is doubtful if seasonal changes extend more than 50 feet below the surface. The temperature in Lake Michigan in the summer at the surface is 64.9°; at a depth of 18 feet, 64.9°; at 74 feet, 44.9°; at 436 feet, 39.5°. The mean surface temperature of the ocean at the poles is about 40°, and at the equator about 80°. At the bottom the figures are 29° and 35° respectively. In the seas, the surface temperature is nearly constant, while at 6,000 feet in the Mediterranean it is 55° but in the Atlantic 35°. The temperature of the shores is greatly modified by the ocean. The farmer at Seattle in January is plowing in a temperature of 40°, while the farmer at Bismarck, North Dakota, is caring for his stock in a temperature of 7°.

Since the air is lighter and drier in the mountains, the earth and rocks warm up quickly during the day but the heat is rapidly dissipated at night, hence the nights are cold. The same thing occurs in arid countries.

Air and Water Currents

In older times man thought that "the wind bloweth where it listeth," but we have come to understand that the currents of air and water are governed by definite laws. In the ocean, where local variations are less, the chief currents are well known and charted. We know why the Gulf Stream flows north, modifying the climate of the Atlantic Coast, and why there are cold currents moving south. We have come to understand the trade winds and can chart on our daily weather maps the progress of the great cyclones across our country. Many were the surprises in store for us when aviation developed and we found all sorts of unexpected currents and eddies with spots of unequal density in air supposedly calm. Much remains to be learned. We know that the United States is in the zone of prevailing west winds, which in large measure accounts for the cold climate of the eastern portion of the country in winter and its heat in summer. The wind, moreover, determines the distribution taken from the ocean and carried by the clouds to be deposited as rain or snow. The presence of a high mountain range on the west coast stops the clouds which gather about its peaks in summer, while the Sacramento Valley, a few miles to the west, swelters in a daily temperature of 100°. In the winter snow piles up to an incredible depth to be available as water supply to the coast in summer, but supplying only a few little streams for the wide arid stretches of Nevada to the east. Barring a little from the north all the water for the rest of our country must work its way north and west from the Gulf of Mexico and the Atlantic. The result is that west of the one-hundredth meridian, which passes through central Kansas, the supply is inadequate for ordinary crops. Another result is that the west coasts of America, as well as of Europe and Asia, taken as a whole, are much warmer and subject to fewer extremes than the east coasts. This is shown by the following comparison:

Place	Latitude	Temperature		
		Mean Annual	Coldest Month	Warmest Month
New York City..	40.8°	51.08°	35.06°	75.38°
San Francisco...	37.48°	54.09°	49.°	59.°

Moisture

The corresponding distribution of fog and cloud are not to be ignored. The visitor to San Francisco who neglects to carry his overcoat when he leaves the hotel in the morning of a sunny, summer day is likely to freeze when the fog rolls in about the middle of the afternoon. The man in New York at the same season is likely to look like a drowned rat if caught far from shelter without an umbrella, but in San Francisco the Sunday-school picnic may be announced a week in advance without the eastern reservation of "weather permitting." London is covered with a fog from fifty to seventy-five days a year. On the north Pacific coast 65 per cent of the days are cloudy; in the region of the Great Lakes, 50 per cent; the Mississippi and Missouri valleys, 45 to 50 per cent; while Arizona and New Mexico have one of the sunniest climates on earth, only 30 per cent of the days being cloudy. Our rainfall corresponds to the same conditions. On the north Pacific coast it varies from 60 to 100 inches annually; lower Mississippi Valley, 30 to 40 inches; upper Mississippi and Missouri valleys, 15 to 40 inches; Arizona and New Mexico, 10 to 20 inches (including areas, however, in which practically not a drop of rain falls for two or three years at a stretch), and the eastern coastal plain, 40 to 60 inches. The effect of mountains on rainfall is most strikingly shown in some tropical countries like Santo Domingo where there is an annual average of 12 inches per month in the mountains while a near-by coast has only 20 inches per year.

Distribution of Organisms

It is becoming a custom among naturalists to classify organisms under three heads: bacteria, plants, and animals, for the first differ in many ways from the others.

Bacteria

Bacteria and the one-celled animals called protozoa are the smallest of living beings. In as much as water is an essential part of all cells, bacteria can live and multiply only in moisture. Some of the bacteria form spores, which we may think of as seeds, and exist indefinitely under dry conditions, but reproduction will occur only where it is moist. The bulk of them are to be found, then, in water or moist earth but since they are so small and light large numbers exist at any given time in the air. Where the air is dryest, therefore, the fewest bacteria are found. In the Alps one observer detected only 345 per cubic meter, whereas 4,750 were found in the air in Paris. They seem to be most abundant in humid regions of warm countries.

Plant Distribution

So obvious, indeed, is the paramount importance of water in its influence on their form, structure, and distribution that the classification of plants into hydrophytes, mesophytes, and xerophytes, based on this criterion, is universally recognized as the most fundamental of all ecological classifications.

Plants which require a maximum water supply—typically, plants that actually grow in the water—are termed *hydrophytes.* Plants which require a minimum water supply, notably desert perennials, are termed *xerophytes.* Plants which are intermediate in their water requirements are termed *mesophytes*: these include the plants of ordinary moist soils.

The soil moisture conditions influence the amount of water which the plant is in position to absorb from the outside world, while the atmospheric moisture conditions influence the amount it is liable to lose through the phenomenon of transpiration, the water actually available to the plant for carrying on its various activities being represented, of course, by the balance between what is absorbed and what is lost. When the amount of available water falls below a certain point, the plant wilts, and two of the greatest sources of danger the plant has to face are insufficient absorption and excessive transpiration.[11]

So varied are the demands of plants that there is hardly a place on earth where some plant does not grow. Even the face of the rocks may be covered with lichen. A trip across our country from New York to San Francisco is a revelation to the observant traveler of the variety of natural conditions and of plant life. He leaves a region brown or white in winter and green in summer, where the plants of China will flourish as well as native varieties, and arrives at the west coast green in winter and brown in summer to find the "gums" of Australia side by side with the olives of Italy. From a region heavily watered he passes to areas increasingly arid until farming is possible only through irrigation. He breaks through the heavily wooded eastern hills to the hillless prairies and understands the Colorado preacher's comment on Iowa as a land where "there is no more scenery than in a pan of skimmed milk." He crosses mountain ranges and sees little patches of scraggly juniper and wonders if some wag is responsible for calling them "forest reserves." The open spaces impress him as large enough to provide for untold added millions of men—until he asks himself how these men are to make a living. Just such contrasts exist in all parts of the earth.

Influence of Rainfall

In as much as the water is seldom available in equal amounts throughout the year, all plants must be adjusted to the peculiar condition of the area they occupy. In Haiti the telegraph lines are festooned with air plants which secure needed moisture from the air, while the trees in Louisiana may be draped in Spanish moss. In the desert, moisture is conserved in the fleshy leaves of cactus or, as in other cases, the roots of the shrubs extend a considerable distance about the plant and are near the surface to take advantage of whatever rain may fall. Growth and formation of seed must occur when the rainy season is on or reproduction may be prevented. When man appears and tries to cultivate this dry country he comes to appreciate the old saying:

> Little drops of water
> On little grains of sand
> Make a mighty difference
> In the price of land.

An annual average of 6 to 10 inches of water makes general agriculture possible, provided the rain comes at the right time. A much heavier rainfall coming in a brief period and followed by a long drought may force man to abandon the territory or change his crops; if the rains are light, the water may evaporate ere the crops are benefited; if very heavy they may beat down and destroy the crops and wash the land. Fog may bring little precipitation but may be very helpful by preventing transpiration, while dew often prevents freezing.

As we go from the equator to the poles we find a certain regularity in the yearly distribution of rain. The equatorial regions have two wet and two dry seasons. Subequatorial and subtropical regions have one wet and one dry season. Deserts lying 25 to 30 degrees from the equator have two brief periods of rain and two hot and dry seasons. In the temperate zone the distribution is very irregular but scattered through the year while in the polar regions the distribution is quite even but small in amount. These phenomena are produced by the rotation of the earth and the other factors already mentioned. In another chapter we shall discuss agriculture under these different conditions. It may be noted in passing that an increase in rain may be a great benefit to man while a drought is always serious. Hann has noted the following increase in wheat in Australia:[12]

6 bad years	13.5 inches rain	6.6 bushels per acre.
5 next best years	15.4 inches rain	10.0 bushels per acre.
7 best years	18.5 inches rain	12.4 bushels per acre.

By contrast we may note a reduction in the corn crop of the United States, due to the drought of 1913, which was estimated at 750,000,000 bushels.

Animal Distribution

The influence of moisture on the distribution of animal life is no less important. The abundance of the lower forms in water and wet regions has been noted already. If these chance to be of the disease-producing types the welfare of the higher forms may be affected. "It is a matter of universal observation that in tick or tick-infested countries dry seasons result in the reduction; moist seasons in the increase of disease; dry localities favorable; moist localities are unfavorable."[13] Malaria has always haunted the lowlands, whereas the mountains have been favored for health resorts. A similar contrast obtains as between wet and dry seasons. With reference to increased rainfall Osborn observes: "(1) it may diminish the supply of harder grasses to which certain quadrupeds have become thoroughly adapted; (2) it may at the same time produce new poisonous or deleterious plants; (3) it may be the means of introducing new insects or other pests, and new insect barriers; (4) it may be the means of introducing new protozoan diseases and new carriers of disease; (5) it may be the means of erecting new forest barriers to migration, or new forest migration tracts for certain carnivora, such as the bears."[14]

There are regions so arid that the native animals never seem to drink water but get their supply from the juices of their food, but the higher forms cannot exist under such conditions. The farmer waters his stock at frequent intervals, and cattle in semiarid regions make almost daily trips of considerable distance to get water, leaving the calves exposed to the danger of attack by wolves. Wild horses go for two or three days without drinking and sheep will go for a week or more if necessary. The power of the camel is well known. Yet the water may carry the germs of disease and be deadly rather than life-giving. We can but wonder if the great plagues of history have occurred in wet seasons. The disappearance of the vast herds of horses that inhabited America long before the advent of man is most easily explained on the basis of some disease. It is interesting to note that fossil flies similar to the tsetse flies which carry the sleeping-sickness in Africa to-day have been discovered in America.

Influence of Snow

In as much as a considerable part of the moisture in the colder countries falls as snow, somewhat different results may be seen. The snow may form a blanket over the earth and protect the grass and bulbs underneath. Wheat suffers much more in "open" winters than in winters with much snow. Animals are often protected by snowbanks. Snow houses are not undervalued by the Eskimo. On the other hand the radiation from the snow lowers the temperature in winter and retards its rise in spring. Hence, April is colder than November. The snow may reflect the rays of the sun and blister the face of man or cause the dreaded snow blindness.

Snow may bury the food supply and cause animals to attack trees or eat the poisonous plants passed by under normal conditions. Horses will scrape away three feet of snow to get at grass, while the cattle perish. The blizzard may bring death to thousands of sheep. The deer will be more exposed to the attacks of wolves if the snow is deep. Heavy snow as well as increased rain may promote the growth of poisonous plants in the country over which stock ranges. The stockmen in Montana have long recognized the danger due to larkspurs, water hemlock, loco weeds, and poison camas. It follows, as a matter of course, that a reduction in the amount of moisture may be beneficial. Malaria disappeared in the Middle West with the draining of the marshes.

Influence of Temperature

The distribution of life is determined by temperature quite as much as by moisture. This statement refers to the temperature during the period of reproduction and infancy rather than to the mean annual temperature. The northward spread of organisms adapted to the tropics is limited by the cold of the north, while the southward extension of colder types is limited by the heat. Merriam has called this the "Law of Temperature Control" and thus states it: "Temperature by controlling reproduction pre-determines the possibilities of distribution; it fixes the limits beyond which species cannot pass; it defines broad transcontinental barriers within which they cannot exist, be the other conditions never so favorable, because of infertility." [15]

It is customary to speak of the temperature under which any form of life thrives best as the *optimum;* the lowest at which reproduction takes place as the *minimum;* the highest as the *maximum.* There are bacteria which will stand for a time the exceedingly low temperature of liquid air without being killed, while some spores will survive dry heat of 140° C., though they are killed by exposure for thirty minutes to moist heat of 120° C. A few varieties thrive best near the freezing point and a few others whose optimum is between 120° to 140° F. The majority do best at 75° to 85° F. It is for this reason that the lowest forms are so abundant in the warmer parts of the earth.

A survey of conditions in North America, north of southern Mexico, made by the Biological Survey of our government, reveals seven transcontinental life zones "each characterized by particular associations of plants and animals." The Boreal zone has a yearly temperature of less than 10,000° and its hottest period is below 64.4° while the Tropical zone has a yearly temperature above 26,000° and its hottest period is over 78.8°.

It is doubtful if there is a spot on earth where some form of life may not be found, but the distribution is very uneven. Contrast the profusion of plant life in the tropics where growth is possible throughout the year with the frigid regions with their short summers and short growing seasons. Compare the dense tropical forests with their long vines with the little dwarf willows and aspens of the far north. The temperatures are quite as great in the United States as in the tropics during the summer and we may grow many tropical plants in our yards but few of them will produce seed, let alone survive our winters. There are no very small mammals in very cold lands. Too much of their food would have to be used to maintain bodily temperature. We do not get our fur-bearing animals in the tropics nor our alligator skins from Canada. For reasons not wholly understood the gaudily colored birds like the toucans of the tropics are contrasted with the gray and white grouse and geese of cold lands.

Plants must produce flowers and seed ere the period of rest appears, which means the dry times in the tropics and the winters elsewhere. Since plants and seed mean food to birds and animals their habits must be adjusted to varying conditions. It is not temperature, as such, which causes the great semiannual migration of birds. Many species that winter in the South could remain in the North if food were abundant. Meadow larks, robins, and others sometimes winter in northern states. The winter of 1925-1926 was light on the Pacific coast and thousands of geese and ducks remained in Alaska. It will be noted that the insect-eating birds are the first to start south in the fall, followed by the seed-eaters, and that the order is reversed in the spring migration. The great horned owl, a permanent resident in the North, nests in February while the quail nests in August or later as does the mourning dove at times. The young of wild animals seem to be born at the time of the year when their chances for survival are the best, and temperature, directly or indirectly seems to be the most important factor.

A similar distribution is found in the ocean. The sharks, barracudas, and angel fish characterize the tropics as much as cod, haddock, and halibut do the cold waters. The body temperature of the cod is about 37°. They refuse to remain in water which falls to 32°. In 1882, a section of the Atlantic, 170 miles in length and 25 in width, was covered with dead tile fish, the number being estimated at 1,400,000,000. They live at the edge of the Gulf Stream at a depth of 600 feet. In this year the stream appears to have shifted its course and the fish perished. In 1892 the stream resumed its old course and the tile fish began to increase and were present in large numbers by 1915. Although there are fossil corals found in Iceland, all living corals are in warm waters, another proof of change of climate in earlier days. Certain fish are always found near the surface, others at lower depths. In Lake Michigan we find the following stratification:

Lake herring	near surface
Whitefish	21-36 meters depth
Lake trout	below 25 meters except during breeding season
Long-jaw whitefish	36-66 meters
Blackfish	70-80 meters (60 in winter)
Hoy's whitefish	below 115 meters usually
Small cottoid	below 115 meters [16]

It is possible that the intensity of the light may be responsible for some of the stratification just mentioned, for the denizens of the deeps seem to come to the surface at night only. Bizarre, indeed, are the forms of fish the dredges bring from the depths of the ocean. Practically no rays of light penetrate more than 350 feet below the surface of the water. Be this as it may, light has much to do with the distribution of life. [17] Many lowly forms like the moles living beneath the surface of the ground are blind, as are the fish in Mammoth Cave. Many of the bacteria, especially those which live as parasites in the bodies of animals are quickly killed by exposure to the sunlight. Few germs survive in the bright sunlight of arid regions. Animals vary in their reactions to light. Owls can see by day but prefer to hunt by night. In ponds the snails seek a faint light, being found in the lightest spots on the darkest days. If a cockroach is set free it will seek the shadow, whereas a fly will seek the light. It is in relation to plant growth that light shows the most marked effects, for the formation of chlorophyll takes place in the light only. The contrast in color of the potato sprout in the cellar and one in the field is known to every farmer. Recently it has been found that some plants from warm regions where the days are short and which did not produce seed in the north could be made to set seed by the simple device of covering them and thus shortening the hours of exposure to light. There is reason to believe that the barring of feathers as seen in many birds may be due to differences of growth as between day and night.

Influence of Wind

The winds, also, have some influence on the distribution of life. They greatly increase the evaporation of water and thus affect the humidity of the air and the condition of the soil. They cause more rapid conduction of the heat from the bodies of animals and thus render them more sensible to lower temperatures, or cause pleasant sensations if the temperature is high. To some extent they influence the distribution of such light animals as butterflies and moths which find difficulty in traveling against the wind. The gypsy moth has traveled northeast from the infection center in eastern Massachusetts more rapidly than it has gone southwest. Any one who has seen the streets of a mid-west city covered with the lint of the cottonwood tree will appreciate the action of the wind. Exposure to or protection from various winds decidedly affects the value of land for agriculture. Farmers in Nebraska have often seen a promising field of corn or oats ruined in a day by a hot wind from the south. Animals are affected as well for some hide when the wind blows. Man himself is not immune. We need not stop to discuss the damage done by tornadoes nor list the benefits of the trade winds. The winds as bearers of the rain clouds have proved their worth to man.

Again we must remind ourselves that in nature all these factors are operating all the time and in reality cannot be separated. Moisture must be considered in connection with temperature, or altitude, or prevailing wind. A moist tropical valley, sheltered from the wind, may be very unhealthful for man owing to the abundance of the lower forms of life, while a similar situation in other zones may be most desirable. "In times of calm, the air temperature may itself be quite unimportant. An unobstructed exposure to solar radiation, combined with a calm condition of the atmosphere makes it possible for certain high valleys in the Alps, which are especially well sheltered, to rival many southern winter resorts, notwithstanding the extreme cold of the winters." [18] In California the Napa Valley north of San Francisco produces some of the earliest fruit for similar reasons.

Let us take one last glance at these cosmic factors. The air contains an enormous amount of dust of many sorts. Much of this will find its way to earth anyhow, but the washing of the air by the rain is one of the real services nature affords. How differently the air smells after a refreshing rain, and how all nature, man included, seems to rejoice! That much of this dust, often poisonous, is man made is another story. The presence of ozone indicates the absence of organic impurities, and ozone is not to be found in inhabited rooms. It is four times as common in the Alps as in Paris. To keep the air fit to breathe may be one of man's problems in the future just as the keeping of the water fit to drink is a major problem to-day.

Organic Activity

The activities of an organism depend on its structure and its response to a stimulus just as iron responds to the presence of oxygen. The bacteria respond to certain stimuli. Drop some salt in a solution containing certain bacteria and they will get as far away from it as possible. Look at the bacteria in the spectrum of a drop of water and they will be found concentrating in the red and yellow sections. They do certain things because of what they are and not because they have any theory as to what they should do. In so far as we know, to mankind alone is reserved the common desire to be something else, as the housewife looks at the cat and wishes that she could trade places. Within very narrow limits the bacteria may move and change their adjustment. Plants cannot, they must live or perish as conditions permit. Animals readjust when possible by movement; in the higher forms by changing habits, yet most of their adjustment to the environment is not self-determined.

Animals must breathe oxygen. The available supply is in the air or in the water. The fish does not decompose the water but utilizes the free oxygen it carries. It cannot live in the air any more than man can live in an atmosphere of pure oxygen. We say, then, that the fish is adapted to his environment, which means that being what it is it must live under certain conditions. Brook trout thrive if there are 5.5 c.c. of oxygen to the liter of water but are driven out by the same amount of carbon dioxide. Plants, on the contrary, flourish if the carbon is present. In an aquarium there is often an excess of nitrogen which is harmful to the fish. The whales and porpoises being air-breathing animals must come to the surface. Yet the whale would soon perish in the air regardless of its food supply, for the thick fat which protects it in water would be fatal under the rays of the sun.

Water and air contain elements both good and bad from the standpoint of animals. Few plants or animals accustomed to fresh water can survive in the ocean and Great Salt Lake is almost devoid of life. If the streams are polluted with acids, or the refuse of mills and towns, the fish soon leave or are killed. The fumes from a smelter may destroy the vegetation for miles. Butte, Montana, once bore the reputation of having neither lawns nor trees. Stone cutters, coal-miners, men who work in the dust of the streets, breathe in so much foreign matter that their lungs are coated, and they are made susceptible to the attacks of germ diseases if not actually poisoned by the dust inhaled if it contains lead or phosphorus.

Movement is determined by structure. The fish swims not from choice but from necessity. The plant grows towards the light and perishes if the light fails. The animal finding itself in a disagreeable situation may swim, run, or fly, as the case may be, to seek other conditions. If it fails, it may perish; if it succeeds, all is well. Complete self-realization, even for man himself, depends on the maintenance of adaptation.

"If animals are placed in situations where a number of conditions are equally available, they will almost always be found living or staying most of the time in one of the places. The only reason to be assigned to this unequal or local distribution of the animals is that they are not in physiological equilibrium in all the places."[19] Their habitat then is selected by "trial and error," that is, if they do not feel comfortable in one place they seek another. Animals of the same species show different habits in different environments and there is a vast difference in the habits of species. "Animals living in the same places, and apparently under the same external conditions of existence, nevertheless behave in quite different ways under the influence of the various substances held in solution by the water, as salt, oxygen, carbonic acid, etc. The ova of different and yet very closely related forms can endure a long period of drought, or even require it to enable them to develop. Hence, every change, as for instance, in the composition of the water of a lake or river will not affect the fauna inhabiting it equally, but will act on some individuals; some will bear the change without being in any way affected by it, others will die, while others again will survive."[20]

Adaptation, then, is essential if the individual or the species is to survive. Yet the conditions of the world are ever varying. "The animal lives in an environment which is constantly changing. Its spontaneous movements are constantly bringing it into different conditions. It tends to regulate its internal processes by selecting the point in the environment in which its internal processes are not disturbed." [21] There are several types of adaptation to meet the daily demands.

DANGERS OF CHANGES

Sudden changes are the most dangerous. The frost kills both plants and insects; the hot wave destroys the corn. Against such disasters life has little defense. The changes which come with the seasons finds nature fertile in inventions and prepared. By means of seeds or buds which remain dormant plant life survives the winter or drought. The insects lay eggs or sleep in larval form. Birds migrate to find new sources of food. Bears hibernate.

There are physiological changes as well as changes in habits. A frog is lively in warm water but becomes sluggish and drowsy as the temperature falls. The blood temperature of hibernating rodents falls to about 40° sometimes nearly 35°. A little oxygen reaches them but they require so little that immersion for an hour in carbon dioxide will not kill them. They must be fat when they begin the long sleep and must waken gradually. It is believed that if their temperature falls too low they awaken automatically, and by movement and the inhalation of oxygen again raise their temperature.

Even the daily changes are significant. Sleep seems to result from a drugging of the system by the carbon dioxide and other substances produced by everyday activity which are less rapidly eliminated. At night, therefore, the eliminating process goes on until a balance is secured again.

Readaptation by change of habits is common among animals and we may say that it is due to their education. Our common chimney swifts formerly nested in hollow trees or crevices in the rocks but have accepted the chimneys as substitutes. Wrens and martins appreciate the houses built by man. The owl will lodge in the church steeple. Ground-building birds like the black-throated bunting will sometimes build in trees if their earlier nests have been destroyed. Birds and animals which are hunted become very wary but ducks and geese quickly discover a pond where shooting is prohibited and gather there in great numbers. The multitudes of ducks and coot which assemble in the autumn on Lake Washington in the very heart of Oakland, California, have made themselves a scenic asset to the city. In parts of Africa the buffalo seems to feed only at night because of constant hunting.

Rhythm in Nature

There is a rhythmic character in nature which has impressed all careful observers. The rotation of the earth producing day and night, the revolution about the sun, the ebb and flow of the tides, the waves of sound, light, electricity, illustrate this in the material world. Birth, youth, maturity, old age and death reveal it in the organic world. The alternating periods of rest and activity, the pulsations of the heart, the inhalation and expiration of the breath reveal it in the activities of organisms.

We may see this rhythm in some of the phosphorescent organisms of the ocean.

> It might be supposed at first that these phosphorescent organisms are not observed to emit light during the day because of the pressure of sunlight, and that if taken into a dark room they would be found to phosphoresce just as brilliantly as at night. Such is, however, not the case, not a spark can be elicited from them even by vigorous shaking, so long as there is daylight in the outer world. But as one stands by and watches in the dark room as twilight is falling outside, although the organisms have been exposed to light all day, one observes the little lamps light up and flash out one by one like coruscating diamonds in the darkness till the whole fish is studded with flashing and disappearing light, a glorious sight in the darkness and stillness. . . . Regularly

every evening the lights come out, and as regularly every morning they are extinguished, although all the intervening time the tiny living creatures have been kept in darkness.[22]

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CHAPTER III

HUMAN GEOGRAPHY

For I have learned
To look on nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused
Whose dwelling is in the light of setting suns,
And the round oceans and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thoughts
And rolls through all things.

—WORDSWORTH

Man, like the other animals, is affected by the forces of nature which have just been discussed, and survives only as he develops or maintains the necessary adaptation. Lightning, flood and tornado do not spare him. He must breathe air and not carbon monoxide; must eat bread and not strychnine; must drink water and not ammonia, if he would live. In two respects only does he display any marked differences from the higher brutes about him. He has a better mental equipment and a naked body. While both of these features worry man a good deal, the former has enabled him to survive and the latter has been a big factor in the death rate of other organisms. It is man's power of adapting himself to all sorts of conditions and of modifying his habits to meet various changes which has given him a wider distribution on earth than other species save those which he takes with him, by design or accident, and for whose needs he provides. Where others fail he can find food and shelter even if he has to develop commerce to supplement local resources.

MAN'S ADAPTATION TO ENVIRONMENT

Moreover, this wide distribution is not a recent event. In all our "discoveries" of new lands like America plenty of "natives" are found and their traditions often assert a local origin with no hint of wide migrations from older homes. Easter Island is remote enough from other places but the great statues there bear silent witness to earlier inhabitants. Cain, reputed to be the son of the first man in one of our oldest accounts, goes to a new home and marries "one of the daughters of the land." We do not know where man originated and most of our stories of early migrations are legends rather than history. Tradition aside, the little evidence we have points to Asia as the original home site of man and as the center of mammalian distribution as well. Even to-day one-half of the human race lives in southwestern Asia. At some date, long prior to our records, man started to roam and made his way to all corners of the earth. Moreover, every group we know is far from being primitive save as compared with more advanced peoples. All understand the art of fire-making, have cooked food and wear more or less clothing. All have tools and weapons. Assuming that the genuine primitive man had neither fur nor clothing it would seem that he must have lived in the warmer regions where the supply of heat as well as food was fairly constant throughout the year. This statement suggests an important fact which must always be kept in mind; that is, that there is a correlation between man's abode and his mental and social development. Wherever man is found there is evidence that he has learned how to live under the conditions that obtain.

The fact is simple but it makes difficult a clear understanding of certain phenomena.

Race and Climate

Taking man as we know him to-day, there is little correlation apparent between his physical traits and the particular environment in which he lives. There is no important difference in the amount or the distribution of the hair of the body as between the dwellers in the tropics and the polar regions. No race has enough to be of great protection against the cold. In general the Europeans have heavy beards as compared with the Negroes, and this might be cited as an indication of climatic adaptation. The evidence is scanty. No such contrast is found between European and Negro women. The American Indians and the Asiatics are as poorly equipped as the Negroes. The inhabitants of the tropics are as likely to be fat as are the Eskimos. It has been claimed that the wider and more open nostrils of the Negro would make it difficult if not impossible for him to survive in the colder regions but many Negroes are living and prospering in New England and Canada and a Negro was with Peary on his dash to the north pole. Every one knows that there are many racial differences, but the attempt to correlate them with racial residence has failed. There is a considerable body of evidence as to the skin color of different racial groups, but the importance thereof is in dispute.

There exists, however, a widespread belief that the Negro is adapted to the tropics as no white man can be. This belief has arisen largely as a result of the effort of the white man to live in the tropics and deserves, therefore, special attention. It is to be noted that as one goes from the equator to either pole he does not pass from a zone of black folks into zones progressively lighter. To be sure, the inhabitants of south Europe are darker than the races further north, but the Swedes are markedly lighter than the Lapps of the arctics.

The Singhalese of hot, humid Ceylon are lighter than the Dravidians to the north. The American Indians cannot be classified in accord with this belief. One of two things then must be true: either the races are not located in the regions to which they are best adapted, or the belief is not well founded. Even so, the darker colored groups may have certain advantages in the tropics, as for instance the Negro with his large sweat glands, and this was the belief of one of our best informed students, the late Dr. Woodruff, who stressed the effects of the actinic rays of the sun.

> Consequently we find that man is invariably covered with a pigment which acts as an armor to exclude the more harmful short rays, and moreover the amount of pigment is in direct proportion to the intensity of the light of the country to which his ancestors have proved their adjustment by centuries or millenniums of survival in health and vigor. It is a simple matter of mathematics to show that the intensity of light under the zenith sun in the tropics is the greatest and that the proportion of rays per unit of surface diminishes as we go north in proportion to a function of the latitude. In addition to this the further from the tropics we go the greater is the layer of air which the rays must pass through and the more of them which are absorbed. . . . Undoubtedly the negro, when in the shade, is able to radiate heat better than whites and this enables him to keep cool in the tropics, but puts him at a disadvantage in the north where a white man can keep warmer with less clothing and less fire in the house. But it is a secondary cause enhancing the first, because when it comes to a question of light and cold, nature makes no mistake, but selects a color to exclude the light. Hence in all cold countries, i.e., steppes, plains, and the arctics, there is pigmentation of a color in the lower end of the spectrum, red or yellow, with variations of brown, olive or copper. . . . All these red and yellow colors undoubtedly enable the native to conserve his heat almost as well as the white man, and, at the same time, exclude the dangerous short waves.[1]

The ideas of Woodruff had considerable vogue for a time, but the application of his suggestions as to clothing proved to be of little value. Later observers do not stress the actinic rays. Our information on this point is still inconclusive.

Whites in Tropics

In the best recent summary of the evidence that I have seen, Gregory[2] remains unconvinced as to the validity of the common belief. He claims that there is reason to believe that the whites can stand the heat waves even better than the blacks and states that the English stokers do better than the Lascar on the Red Sea. Kanakas were taken to Queensland to work for three years. Their death rate from 1891-1895 was 42.73, from 1896-1900 it was 30.08, whereas during the same time the death rate of the white population including children and aged was only 12. The Kanakas were excluded by the law of 1901, but the white laborers have stood the climate and the production of sugar has increased. The difficulty with this illustration is that the whites were a selected group which lived under much better conditions than did the Kanakas. Agra is more healthful for the whites than Bombay, which has a lower summer temperature. The crude death rate in Queensland is lower than in the rest of Australia. The planters at Darjeeling at an altitude of 600 feet are reported healthy.

Gregory calls attention to the fact that there are a number of white colonies in the tropics which have prospered. The Dutch colony of Kissav in the Eastern Archipelago, founded at least as early as 1783, and whose climate is called bad, was visited in 1922 by Elkington, who reported "no obvious evidence of physical degeneration." "There is nothing in the available history of these people to show that a tropical climate *per se* has tended to produce degenerative effects upon them or to limit fertility," yet many of them are blonds. The German colonists in tropical Brazil, Espirito Santo founded in 1847 and now numbering 17,000 or more, and Santa Katherina with some 85,000 inhabitants of the second or third generation, are said to have better health than the natives. Gregory quotes Arthur Balfour to the effect that the physiological results may be important and that they "are at present the only beacon-lights which may guide us to the haven of certainty."[3] There are many thousands of whites who have lived for generations in Porto Rico likewise. The weakness of these illustrations is that the colonies are in regions carefully selected as suitable to whites, while Porto Rico is a subtropical island very favorably situated.

It is freely admitted by all students that the movement of people to a new country may involve exposure to new diseases and that the resultant death rate is often very high. The Madeira-Mamoré Railroad built in Brazil between 1903 and 1913 is a case in point. Some 400 of 600 German laborers died and the Spaniards, Greek and Barbadians suffered equally. It should not be forgotten that the death rate of all tropical dwellers has been very high without regard to race. Gorgas made Panama healthful but the money cost was enormous. It is admitted also that it may be impossible for any race to maintain standards of work in the tropics to which it has been accustomed elsewhere. In the effort to maintain such standards many have doubtless broken down, and if to disease there has been added recourse to alcoholic stimulants moral as well as physical degeneration is not surprising.

> Practically every northerner who goes to the Torrid Zone says that at first that he works as well as at home, and that he finds the climate delightful. He may even be stimulated to unusual exertion. Little by little, however, he slows down. He does not work so hard as before, nor does the spirit of ambition prick him so keenly. On the low, damp seacoast, and still more in the lowland forests, the process of deterioration is relatively rapid, although its duration may vary enormously in different individuals. In the dry interior the process is slower, and on the high plateaus it may take many years. Both in books and in conversation with inhabitants of tropical regions one

finds practical unanimity as to this tropical inertia, and it applies to both body and mind.[4]

The reader will see the relation of this statement to the problem of disease.

An Australian student, Taylor, has written recently in much less hopeful terms of the white man in the tropics. "The chief definite disability resulting from tropical life is found to be *tropical neurasthenia,* which we learn is associated with depression, irritability, loss of mental activity, and power of concentration." He finds admission to hospitals more numerous than in temperate Australia, from such complaints as dengue, typhoid, alcoholism, etc. "Personally I believe that an adult male, employed in outdoor work, can live as healthily in our tropics as anywhere else. I do not think that this can be said of the women and children, who are even more important in the closer-settlement problem. But it is difficult to get convincing data, as I have stated before, when we come to the somewhat different but vital question of comfort there is no room for argument." [5] Taylor is doubtful about any extensive settlement even of Queensland.

Huntington is likewise skeptical. "Excessive irritability, shortness of temper, is another feature among white residents of the tropics. It cannot be doubted that the discomforts resulting from high temperatures and high humidity are responsible for much of this. One is in a continued bath of sweat day and night, and sleep is difficult and does not refresh one during the wet season at any rate." He found that the death rate of persons born in Queensland was higher than for those born elsewhere in Australia and that women suffered more than the men.[6]

That which seems clear from the foregoing discussion is not that the white race cannot survive in the tropics in so far as light and heat are concerned but that all men living there are handicapped by disease and may be unable to exercise the energy necessary to build up a great civilization. Disease may be conquered and then experience will show the importance of the other factors. One-half of the human race lives between the degrees of 20 and 40 north and this it will be noted, excludes Europe, the most densely populated continent. Primitive man may have thriven best in warmer regions but later man has found his greatest opportunities in colder regions. We should not forget that the temperate regions are often hotter in summer than the tropics, for a few days at least.

World Population

A glance at a globe will show that the great land areas of the earth are in the Northern Hemisphere. The total population of the earth must be estimated, as few countries have an accurate census. The following table shows the distribution of population for 1923:

Continent	Area in Square Miles	Population	Density per Sq. Mile
Africa	11,760,567	135,000,000	11.5
Asia	16,997,639	1,120,740,000	66.0
Australasia	3,317,762	8,606,000	2.6
Europe	3,833,567	571,311,000	148.9
North America	8,631,657	148,273,000	17.1
South America	7,184,021	67,045,000	9.5
Total (excluding polar areas)	51,725,335	1,940,975,000	37.5

Even if a table such as the one just given could be made wholly accurate, the impression given might be very misleading. Egypt, for instance, has a density of 38 per square mile. But the desert areas of Egypt comprise 335,000 of the 347,000 square miles of the country and have about one inhabitant for every three square miles while the Nile Valley has about 1,100 per square mile. Similar contrasts, though seldom so striking, are found in all countries. Even a relatively small area like one of our states usually shows an uneven distribution. Compare Iowa with Utah. According to the census of 1920, Iowa had a population of 43.2 per square mile and this is evenly distributed, owing to the absence of large cities and the almost universal pursuit of agriculture to which all parts of the state are adapted. Utah, showing a population of 5.5 per square mile, has almost the entire population in a few valleys while great areas are uninhabited. Detailed maps will show that the great populations of the earth are found in the river valleys like the Ganges and Yangste and usually not over 600 feet above the sea level. Rhode Island has a density per square mile of 566.4; Nevada only 0.1, and the difference is not explained by saying that one is "old" and the other "new." It seems clear that the location of population is determined by something, but the student must beware of accepting any narrow idea of "geographic determinism" for the present situation of any part of earth must be considered in the light of its own history and the stage of development of its inhabitants. In what ways, then, does nature influence man?

INFLUENCES OF NATURE UPON MAN

Physical Effects

Every one knows that the growth of the body is conditioned upon an adequate supply of food and drink as well as exposure to sunlight and that crippling of some sort results if the supply is inadequate. It is equally obvious that exposure to sun, wind, and rain will produce marked changes in the color of the skin, as illustrated by the beach guard at the end of the summer. The burning of the skin by rays reflected from water or snow and the damage done to the eyes are as well known. Any change in food, drink, or exposure is likely to produce a temporary upset of the body functions, more or less serious, as in the changes in altitude already noticed. Exposure to cold may cause frostbite or even death. It is quite possible that the development of men in different parts of the world will vary somewhat. "We can hardly err in attributing the great lung capacity, massive chests and abnormally large torsos of the Quichua and Aymara Indians inhabiting the high Andean plateaus to the rarefied air found at an altitude of 10,000 or 15,000 feet above sea level." [7] If man changes from a poorer to a more favorable environment, better development is to be expected. We find this in plants taken from alpine conditions and grown in the lowlands. The descendants of Europeans living in America and Australia are believed to be larger and stronger than their ancestors, just as the men of to-day are larger than those of the Middle Ages. While these facts have been generally admitted there has been little effort to study and classify them nor do we know their limits.

There are many indirect physical effects which may be attributed to nature. They may be summarized as the varying types of development of the body due to different occupations. Darwin attributed the thin legs of the Indians of the Paraguay River to their constant use of canoes. The farmer walking over soft ground develops a different gait from the dweller of the city pounding his heels on hard pavements. The cowboy and the sailor develop somewhat similar peculiarities. The pianist and the typist acquire marvelous dexterity with their fingers. The human body responds, in other words, to the special training given by constant use of any part. There is a widespread belief that the human face reflects daily activities but the attempt to determine career from photograph has produced results amusing rather than accurate.

Influences on Occupations and Activities

The daily round of man's activities is largely dependent on light, temperature, and weather, and from their influence he cannot escape, no matter how great control he develops. Man may grope his way across a field at night but he must be able to see in order to gather food or cultivate the field. But the sun may make the day so warm that effort is painful and man may have to rest till twilight, or wait for a moonlight meeting with his friends. The storm may confine him to the house, happy in the enforced idleness, or worried about fuel and food, as the case may be. The alternating seasons produce a rhythmic swing in his activities which varies with his location north or south of the equator. A careful scrutiny of birth, morbidity, and death rates will show that they are not even throughout the year but rise and fall in interesting fashion. Crime is as closely related to weather as church attendance. Nature influences group movements as well as those of individuals. The migrations of man depend on food supply, snowfall, and similar things as clearly as does the migration of birds. The Indians could not carry on long campaigns against the whites, far from their homes, because they could not carry the necessary foodstuffs. The campaigns against the government in Haiti usually took place when the mangoes were in fruit. It is out of the range of possibility to do more than suggest these facts at this time but they need to be mentioned because man so easily gets the notion that he has escaped from the control of nature. It is true that the average man in civilized lands deals seemingly more at secondhand with nature and has lost the training which comes from the immediate contact with basic occupations, but this is only a small part of the situation.

In as much as all plants and animals are to be found within given areas and not elsewhere, since coal and metals are here and not there, it follows that the occupations of men, since getting a living is the fundamental occupation, bear a definite relationship to local opportunities. At first all that man has is of local origin. Later on the growth of commerce between places of different types makes possible, and often profitable, a specialization in industry. The savage on the sandy seashore must eat oysters or clams until he learns to catch fish. Even here the warning against overemphasis on geographic determinism is needed. Man does not always do the best or most obvious thing. He may starve rather than eat clams if he has grown accustomed to a fish diet. It is much safer to see what man has done in any given place than to predict what he will do. That is to say that nature and man are relative rather than absolute terms. Man will be more likely to prosper if he does certain things; that is all. Many things he cannot do but he may try them. One of the announced projects in the founding of the Virginia colony was the production of wine, but two hundred years elapsed ere a cultivated grape suitable to American conditions was produced and the colony was saved by the growth of a plant unknown to Europe, tobacco. With these qualifications we may predict that a South Sea islander must be a fisher with some little help from coconuts. The dweller in the woods must depend on hunting or the gathering of wild fruits. The dense tropical woods have been peculiarly unfavorable places for human culture, for the fruits and the game were in the tree tops and the ground was too shaded for plant growth. The dweller in the arctics must be a hunter and fisher, for agriculture is impossible. Yet, if contact with some settled country in temperate climes can be maintained, he may be a miner, or if some peculiar animal like the reindeer can be imported he may revolutionize his life as has the Eskimo in parts of Alaska. The opportunity offered by any region must always be considered in relation to the stage of development of the people who are there or who come there. Iron was here but the Indian could not use it. The Indian planted corn but he could not cultivate large areas for he had no draft animals. To understand man's relation to his opportunities it will be found helpful to take some area whose general character is well known, like the United States, and then analyze the old Indian culture. Why were the Iroquois relatively prosperous and the Piutes relatively poor? Why were the Atlantic coast Indians so well developed and those of the Pacific coast so backward, if California has its alleged advantages? Why do we find in the far southwest ruins of irrigation ditches indicating that hundreds of square miles of land had been under cultivation at some time, whereas in Utah no such ruins are found in the very areas irrigated with so much success by the Mormons? Such are the questions the student must answer, for out of them grow the problems of society.

The problems of the Indians have been used as illustrations because no known question of differences in racial equipment enters to arouse our emotions or confuse our judgment. History shows that the culture areas have offered very unequal opportunities to man and that no group, regardless of race, could prosper or advance if the opportunity was lacking. History also shows that man has responded to the varying opportunities sometimes in surprising fashion. The early colonists from Europe to America were in substantially the same state of development but note the differences that arose. The New Englander turned to fishing, to shipbuilding, to trade, or moved west to grow grain and live stock. The southerner turned to cotton and tobacco. A vast series of differences in social and political customs was the result.

If man is to carry on settled industry he must have a place to live, a house, fire for food or heat, clothing. Whence are to come these necessities? Obviously from the neighborhood. From the cave of primitive man to the wigwam of the woods Indian and the skin-covered tepee of the plains dweller to the adobe house of the village Indian and the brick or stone structures of our cities, the influence of local resources is plain.

Influences on Migration and Commerce

The movements of man show a clear response to nature. Down to the seventeenth century the oceans offered the greatest obstacle to the migratory hordes, and not until the advent of steam power in the nineteenth century did the oceans really become safe and easy highways. Yet the South Sea islanders had made wide voyages in their little canoes. As checks to man's movements deserts probably occupy the second place and, owing to their shifting sand and the danger of sudden washouts, are still great handicaps. Third in importance have been the great mountain ranges and they probably rank first to-day considered in relation to modern methods of transportation and the cost of lifting heavy trains over the divides. There have always been passes through the mountain ranges and man's route has always run through the pass, hence the pass has been of great importance in human history. The Brenner Pass through which the Germans made their way into the Po Valley was largely responsible for the commercial life of Augsburg, Ratisbon, Nuremberg, Leipzig, and, in part, Venice. Students of American history well know the importance of the Mohawk Valley, Cumberland Gap, South Pass and Truckee Canyon. Rivers have been both obstacles and highways. The course of development has been somewhat as follows. When man began a migration he followed the easiest road. Perhaps he ascended a river by boat until he reached the fall line and there, owing to necessity of changing to smaller boats, a town arose which became a city. It may be that he followed the general course of a stream with his stock keeping to the edge of the hills to avoid the marshes of the banks. If population grew and trade sprang up his permanent road followed his early trail, just as in America the white man followed the trail of the

Indian and as the Indian himself probably followed an earlier animal trail. The railroad was invented and it took the same general course. Through the low Mohawk Valley, 445 feet above the sea level, was the line of march to the Great Lakes and the West. Albany, Troy, Utica, Rochester and Buffalo come into being and the valley is densely populated while the Catskills near by are almost uninhabited. It is interesting to speculate what would have been the history of America had the St. Lawrence been navigable from the ocean to the lakes. Where, for instance, would the capital of the country have been located? The location of man's towns and highways is not, then, a matter wholly of accident. Political considerations have determined the site of a few cities like Petrograd, Washington, and Canberra, the new capital of Australia, and even with reference to these we might ask the cause of the political considerations. Migrants go to the places where they have opportunities for gaining a livelihood, and booster's campaigns have little lasting influence.

Psychical Influences

Strange as it may seem, man lives in two worlds, not one. As a part of the first he receives impressions through his senses and is stimulated to action. He then reflects, combines and mixes his memory and impressions, and creates a new world out of the old elements. The first is a world of rocks, trees, animals, birds, men, all tangible. The second is a world of spirit, which may be seen or felt but seldom grasped; immaterial but often dwelling in carnal shapes. It is not easy, always, to tell where the boundary lines between the worlds are. Man requires light in order to see but often he perceives more things when it is dark. Ghosts, fairies, demons, goblins all dwell in the second world. The scientist is studying and classifying the material world but poets and dreamers hold sway in the second. Granted this confusion, certain facts appear.

It is man's contact with the material world which has started his mind into activity. Nature by determining his activities plots the road of his development. Why is it that in our part of the world the weather holds first place in our conversation? It is claimed that in arid lands the primary topic is water. Here, then, is a topic in which two men, even though they be strangers, are sure to have a common interest. The Samoyeds of northern Russia have a dozen terms to distinguish the shades of brown and gray of their reindeer. The Malay vocabulary is rich in nautical terms. Language always reflects interest. Get a man and a woman to describe some woman's costume and ponder the result. A new invention like the automobile or radio almost revolutionizes common idioms. Language also gives a clew to the efficiency of our sense organs. Most of our impressions are through the eye and terms for colors and forms are numerous. Contrast our poverty in adjectives to describe odors and see how inadequate our language would be for a dog. We note resemblances rather than differences and only much practice enables us to distinguish similar forms. How many can tell a song sparrow from an English sparrow, a spruce from a fir? It is easy for a farmer to understand and sympathize with another farmer but it is just as easy for him to misunderstand and revile a Wall Street banker. Human standards grow out of human backgrounds and if the backgrounds are different understanding and sympathy are hard.

Man's emotions are aroused by many things in nature. Dexter writing of the dry winds of Colorado says: "During the prevalence of such, the humidity is invariably excessively low, and in the dry air there seems to be set up, by the movement of the wind particles and the leaves and grasses set in motion by them, an electrical state which in some undetermined way makes havoc with the emotions."[8] Huntington writes: "In eastern Turkey the hot desert wind causes the whole community to become cross and irritable. I have there seen a missionary, a man of unusual strength of character, shut himself up in his study all day, because he knew that he was in danger of saying something disagreeable." [9] Hann claims that: "Damp air and increased pressure have the following physiological effects:—nervous depression; quiet sleep; increased elimination of carbon dioxide; slower circulation of the blood. Dry air and decreased pressure, on the other hand, have these effects:—nervous excitement; sleeplessness; quickened pulse; a dim skin and a decreased temperature." [10] Many witnesses have testified as to the influence of the winds.

Writing of the Yukon, a resident says that all are much affected by the highly electrified winter atmosphere:

> By the end of March (the most unendurable month in the North, physically and psychically) we are most of us avoiding and hating one another. I have learned since that this is all a yearly phenomenon and will pass surely and quickly with the breaking of the ice in the river. . . . But there are always the March scandals . . . conventional restraint is broken . . . someone goes crazy or jumps a martial claim . . . or a lonely miner pulls a gun on his best friend with whom he has been living all winter in a too isolated intimacy. . . . To tell the truth, the spring scandal brings a blessed relief. With the spring comes a truly new life . . . neighbors who have not spoken for weeks greet one another across fast-melting back lots.[11]

Every one is more or less conscious of the influence of nature on his emotions. The entrancing beauty of some moonlight scene, the majesty of a snow-capped mountain, the grandeur of the oncoming storm, the restfulness of a mountain pasture filled with sheep are the stuff of which poems are made but for most of us the actual creation is by proxy. Man is terrified by the thunder, he is soothed by the gentle fall of the rain or the music of the waterfall. Color of landscape and cloud moves him deeply. Here is a great field not yet clearly defined and studied. Hellpach has made a preliminary survey but much study and many experiments must be made ere we can hope for much understanding.

Nature not only stimulates our mental machinery into action but sets the limits beyond which it may not go. Our ideals develop out of the world we know whether we consider our experiences good or bad. The Navajo shepherd, accustomed to the arid country where cattle and sheep must graze over large areas, listens to his fellow tribesman tell of the wonders of Chicago and believes it all until the narrator says that on his way he passed vast fields where the grass grew so thick that the blades pushed against each other, and then he is convinced at once that the narrator is lying. Grass does not grow that way, and he knows grass. The Hopi woman hears with amazement of the location of New York City almost surrounded by water and thinks that conditions there must be heavenly whereas our preacher is likely to describe it in other terms. He who knows "the desert's scorching sand" can picture a future place of punishment in no stronger terms; the plains Indian portrays heaven as a happy hunting ground; the dweller in frigid regions can imagine no future place too hot for comfort. "In all the forms of its creeds and cults, humanity does not seem able to get away from its earthly patterns. The Elysian fields, the Valhalla, the life that now is reflected upon the life beyond, are all shaped after models familiar upon the earth."[12] Even our wildest dreams but consist of bizarre combinations of many elements already familiar to us in everyday life. We picture God as a spirit, but it is significant that we picture him in human form for that is the highest thing we know.

Civilization and Climate

In the previous chapter it was suggested that each variety of plant or animal flourished best under certain conditions to which the name optimum was given. Can such an optimum be found for human beings? Certain difficulties confront us in our search. As a rule each group of human beings prefers its own environment and questions the validity of the premises we are likely to accept. We pity the Eskimo but he does not envy us nor does he desire to live as we do. The Arab nomad sneers at our standards of achievement and prefers his own life. If we make achievement the basic factor in our scheme we are bound to find an answer which accounts for the success of the groups of men now dominant on earth. Recognizing these limitations and admitting the influence of nature on man, let us see what evidence can be found.

Man has dwelt in all climes from the poles to the equator in all periods of time known to us. In most of them he has not only survived but has increased in numbers. Nevertheless, a little study will show that all of the great cultures of man have arisen in the temperate zones with some indication that man tends to press in to the colder rather than the warmer regions as he develops. There seem to be three or four possible causes for such a fact: (1) Nature may offer greater and more varied products needed by man in the temperate zones than elsewhere. (2) Disease may be more prevalent in certain regions. This is evident if one compares the polar regions with the tropics. (3) Certain climates may stimulate man to greater efforts than others. (4) Shifts in climate may account for the changes in location of man's civilizations. The last two points are the ones which concern us most.

Huntington has studied the seasonal variations in health and energy of workers in Connecticut and Pennsylvania. The accompanying figure[13] illustrates

the effects of weather not only on health but upon energy in general. The lower curves show the death rate in Connecticut (*C*) in Pennsylvania (*D*) from 1910 to 1913 among persons more than two years of age. The curves are inverted so that good health is indicated by high parts and poor health by depressions. The two upper curves show the average hourly earnings of piece workers in three Connecticut factories (*A*) and in a huge Pittsburgh factory (*B*) during the same period. Notice how nearly the four curves vary in harmony.

Follow the curves through the four years. Without exception they are low in winter. In the summer of 1911, which was extremely hot and trying, especially in New England, they all show a dip, while in the summers of 1912, and especially 1913, when the hot spells were short and well separated, the heat had almost no effect. In the late autumn the curves for health drop sooner than those for energy, which seems to mean that the approach of cold weather at first stimulates people who are in good health while those who are feeble feel an ill effect from the low temperature more promptly. In winter, however, a drop in energy is regularly followed by a long period of poor health.

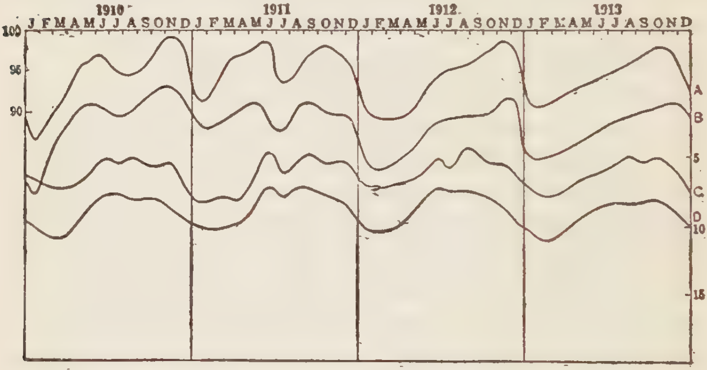

Fig. 1. Seasonal variations in health and energy in Connecticut and Pennsylvania

Work of factory operatives in (*A*) Connecticut and (*B*) Pennsylvania; health (death rate inverted) in (*C*) Connecticut and (*D*) Pennsylvania. Scale for *A* on left and *C* on right; *B* and *D* are placed below the others for convenience, though really belonging at essentially the same level. (From Huntington and Williams, *Business Geography,* John Wiley and Sons.)

The four curves fluctuate so closely together that they seem to be subject to the same influences. The four factories were engaged in different kinds of work; there were no strikes, labor

> troubles, or shut-downs to cause fluctuations in any of them; and the cities of Connecticut are 400 miles from Pittsburgh. There were no epidemics of any importance to cause the curves of health to go up and down together, and the agreement would be equally great if all contagious diseases were omitted. The only factor which seems competent to explain the curves and which varies approximately, though not exactly, the same way in both places is the seasons and the general character of the weather.[14]

Huntington has studied several thousand workers in factories from Connecticut to Florida and some seventeen hundred students in the schools at West Point and Annapolis and his findings are in close agreement with those of the Bureau of Mines and the health departments of various cities. He found that when it was very cold out of doors the activities of all groups were lessened. All groups were most active when the average temperature was from 60° to 65° F. with the noon temperature at 70° or over. Mental activity reached its maximum when the outside temperature averaged about 38°, that is, with frosts at night. Even temperature was not favorable and the best work was done when there was some daily change, but sudden and violent changes were not beneficial. Moderate changes with frequent cooling of the air gave the best results. There was a marked reduction of work in very dry weather and more work was done on cloudy than on bright days. Huntington and Williams summarize the optimum condition as "an average temperature of 64 and an average relative humidity of 80 per cent" which would together mean a daytime temperature of 66° to 70° and a relative humidity of 50 to 70 per cent. Huntington believes that the most important climatic factors are (1) the mean temperature, month by month, (2) the amount of change from day to day, and (3) the relative humidity.

He then proceeds to map the world to discover where the best climatic conditions are found, that is, where the greatest

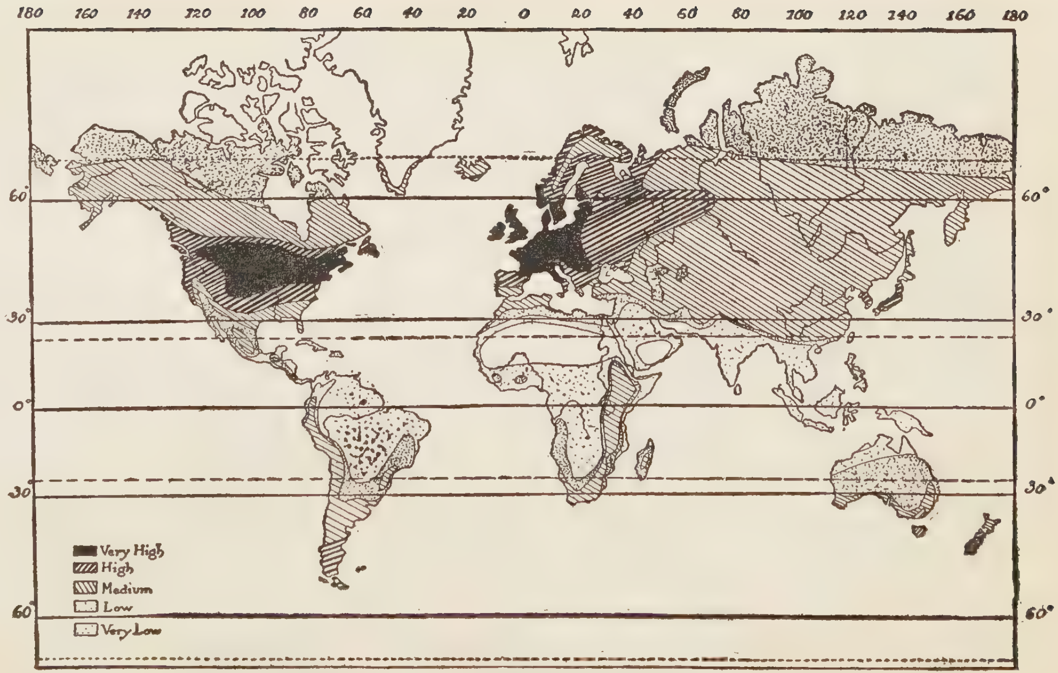

FIG. 2. DISTRIBUTION OF ENERGY ON THE BASIS OF CLIMATE [15]

human energy will be developed if men elsewhere do what they have done in the factories studied. He finds five such areas: (1) western and central Europe to the borders of Roumania and Northern Italy, (2) North America east of the Rockies from southern Canada to the thirty-eighth parallel, (3) the Pacific coast, (4) Japan, (5) New Zealand and the adjacent corner of Australia. Is it mere chance that these are the seats of the most progressive civilizations of to-day?

It is well known that climate has changed over vast sections of earth, indeed may be ever changing. The deserts of Gobi and of Sahara show evidence of having had streams and human inhabitants at some past time. The ruins of irrigation ditches in our own arid Southwest indicate a population impossible with present supply of water. More than any other living man Huntington has studied this question and has traveled widely in quest of evidence. He is far from claiming as asserted by some of his critics that "history is nothing but a matter of geography" but he has given careful attention to the influence of climate on history and his opinions deserve consideration.

> Since most regions where civilization was once high but has now greatly decayed show signs of adverse climatic changes it seems . . . that the relation of climate and civilization was probably the same in the past as at present. That is, climate appears to be the main factor in determining the broad general outlines of the distribution of health, energy, civilization, and productivity. But, on the other hand, relief, soils, minerals, and facilities for transportation, and likewise migration, natural selection, racial inheritance, parasitic diseases, food, clothing, shelter, occupations, density of population, and stage of culture introduce great modifications in the distribution which would result from climate alone. They lead to such features as the brilliancy of Athens in the past, the present remarkable development of Hawaii, and the contrast between the Black Belt and the Kentucky mountains. Yet climate still seems to remain the

most widely effective of all the great factors in determining the distribution of human activity and productivity.[16]

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CHAPTER IV

MUTUAL AID AND THE STRUGGLE FOR EXISTENCE

So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller fleas to bite 'em
And so proceed ad infinitum.

—Swift

The Organic Complex

Long, long ago the seer could state that "no man liveth unto himself." Only yesterday did man begin to understand that this statement was but a small part of the truth and to see that every form of life influences every other form, directly or indirectly. Even this statement is inadequate, for the surface of the earth is itself modified by the activities of the various organisms. Though countless details still escape our observation, the main outlines of the picture are becoming clear. Our first task is to find the facts, the second, to interpret them. A word of warning is necessary. It is as hard for us to avoid a man-centered interpretation of the interrelations of the different forms of life as it was for our ancestors to avoid an earth-centered interpretation of the universe. We are likely to ascribe human motives to the actions of animals. The fact is, however, that we have no right to assume that the influences to be described have any deliberate or conscious cause in the plants or animals themselves. In most cases they must be in entire ignorance of the results of their actions and, not infrequently, this is true of man himself. In other words, they do what they do because of what they are and for that they are not responsible.

Therefore such words as "good" or "bad" are inapplicable, and misleading. In as much as language must be used the reader will have to make the necessary corrections to avoid error.

Effects of Plants

Plant life has no small effect on the contours of the earth. One has but to compare the arid with the humid regions of our own country to see this. In the humid parts the grass binds the soil on the hills and valleys and on embankments made by man. The rain comes and the floods overflow the valleys. Rarely is any great harm done. In the arid country the rain causes great washes in the hills, destroys railroad embankments, and leaves an impassable mass of rock where yesterday was a good highway. The trees and the grass hold the moisture, delay the melting of the snow in spring, thus maintaining a more even water supply as well as preventing the dangerous floods which come when the hillsides are laid bare. Plant life markedly affects the make-up of the air and water either by increasing or decreasing the amount of various gases they contain. The excess of nitrogen in the aquarium so injurious to fish may be removed by plants just as the carbon is taken from the air. Plants furnish a considerable amount of water vapor to the air. The Washington Elm at Cambridge, Massachusetts, was studied by Pierce of Harvard. He found that it had some 7,000,000 leaves with a surface area of 200,000 square feet, or nearly 5 acres. He estimated that this one tree supplied some 32,000 quarts of water daily to the air. The influence of a great forest can be imagined. Thus the forest will increase the humidity of the air, decrease the violence of the storms and offer protection against hot winds as well as furnish shade, welcome to many smaller plants as well as to the animals and man. The roots of trees penetrating the lower layers of the soil, ultimately dying and decaying, will modify the conditions of the soil itself. Indeed, the formation of the soil is largely a matter of the activity of organisms, as will be shown in a later paragraph.

Effects of Microörganisms

For ages man had divided the organic world into plants and animals and had thought it easy to distinguish one from another. How easy such a definition is the reader will discover if he tries to make it. In 1683, Leeuwenhoek, a Dutch maker of lenses, put a couple of them in a tube and found that he had a compound microscope. It magnified objects about 150 diameters, or only about one-tenth as much as our present microscopes, but it revealed a new world. With it he examined many things and found all sorts of minute organisms moving under the lens. He called these "animalculæ," for plants were not supposed to have the power of motion. Even to-day there is a dispute between botanists and zoölogists as to the proper classification of many of them. For present purposes we may divide the organic world into microörganisms, plants and animals.

The microörganisms are divided into four main classes. Among them we find minute animals, the protozoa, which appear to feed on bacteria and other minute organisms. They multiply by fission and have the power of encysting themselves and thus of surviving through bad conditions for considerable periods. Some of them are causes of disease. The bacteria, proper, are single cells averaging about 1/25,000 of an inch in diameter. It takes about 15,000,000 typhoid bacilli to weigh an ounce. They multiply by fission, though some of them produce spores which are, however, very different from the spores of ferns as each bacterium produces but one or a very few spores at most. This seems to be a device of nature to enable them to survive in time of need, as they live indefinitely in spore form. Bacteria produce nearly all the putrefaction and decay found in nature. The yeasts are single cells, round or oval in form and about 1/5,000 of an inch in diameter. They are the cause of fermentation. The fungi are a large and varied group having two common characters. They have their cells arranged in long threads, often almost microscopic in diameter, although the fruiting bodies above ground are often large as in the case of the mushrooms and puffballs, and they contain no chlorophyll. The molds are simple fungi whose fruiting bodies are usually visible, and which cause over half of all known plant diseases. The fungi increase by spores. It is but a short step from the fungi to the lowly plants called algæ which contain chlorophyll.

From the standpoint of their food supply there are three main groups of bacteria. Some are autotrophic, growing in the darkness of the soil and feeding directly on mineral matter, getting their energy from simple compounds such as ammonium salts and methane. Most of them are saprophytes, feeding on the dead tissues of organisms. Some are parasitic, attacking live tissues and producing diseases. It is to be noted further that while a few bacteria may utilize the sunlight, most of them are killed by direct exposure to the sun, the short rays being most fatal to them. Few bacteria attack the living tissues of plants or animals.

All animals must get their food by breaking down the compounds prepared by green plants. Here lies a great difference between plants and animals. In some way not clear to us, plants under the influence of the sunlight are enabled through their chlorophyll (leaf green) to build up out of a few common elements the great series of hydrocarbons and other compounds which animals can incorporate but cannot produce. "All flesh is grass," as the poet sang. Man may eat a little salt or take small doses of chemicals as medicines but he must depend on presynthesized food.

ORGANIC PROCESSES

A hint is thus given of the two great processes in nature which are to be interpreted as complementary rather than antagonistic. The first is the synthetic or building up of organic substances out of the raw materials of earth, and the second is the tearing down of the compounds to simpler forms to make the material again available for other organisms. Both are necessary. If the building up process went on without interruption, all the available elements in air, water, and soil would ultimately be incorporated into plant form and life would become impossible. The tearing down, then, of older organisms makes possible the existence of later generations. It is evident that in the actual world some of the substance is carried away by water and buried so deeply in the mud that no immediate use thereof is possible, but long ages later, perhaps, man digs out some of it as coal and starts the process anew. It is obvious that all the building up is done by organisms. It is less obvious but equally true that practically all of the tearing down is done by organisms and that much of both processes is done by these microorganisms. That which becomes clear is that any given type of organism owes its existence not only to the qualities given it by nature but to the various things done by other organisms. If we agree to call that action which helps another organism a "service," and that which is harmful, an "injury," we shall save much time and yet avoid self-deception. Everything turns on the viewpoint. Let us note, then, some of the chemical changes brought about by the microörganisms which may be classed as services.

Bacterial Chemistry

Some of the elements needed by plants, such as phosphorus and potassium, are usually found in the rocks in insoluble form. Bacteria, however, produce carbon dioxide and organic acids which can dissolve these substances and thus make them available for plants. The same is true of sulphur. Nitrogen is common in the air and a good deal is found in the upper layers of the soil. The Romans knew that the legumes such as peas and beans seem to make the soil richer for other plants. After 1875 there were a number of discoveries showing that some fourteen different sorts of bacteria penetrated the roots of legumes, producing little knots or swellings, which took nitrogen directly from the air and made it available for plants. Alfalfa, if the proper bacteria are present, is said to put at times twenty-five dollars' worth of nitrogen into an acre of soil per year. This is a service the importance of which can scarcely be overestimated. Yet the bacteria may cause also some loss of lime and magnesium to the soil and this may be listed as an injury.

Soil fertility turns in considerable measure on the presence of humus, which is nothing but partially decayed organic matter. This humus has to be broken down into simple forms and this is largely the work of bacteria of many sorts, for no one type can do all the job. The proteins are broken down into ammonia and this into nitrites by bacterial agency. Then the nitrites combine with bases such as calcium and magnesium to form the nitrates on which plants feed. There are also other bacteria which may break down the nitrates and set free some of the nitrogen to the air, thus competing with the plants for foodstuffs. The question of the carbon supply is also very important. Rye straw contains 40 per cent carbon by weight. An acre of beech forest demands nearly a ton of carbon per year. But the carbon in the tree is not much eaten or digested by animals and some of the carbon in the bodies of animals is not available as plant food. The bacteria step in again and by a series of processes make the carbon once more available. Soil fertility is not, as formerly thought, solely a matter of the presence of given amounts of certain chemicals but turns in large measure on the activity of bacteria.

Soil Formation

The share of certain lowly forms of animal life in the formation of soils is not to be overlooked. Darwin was much impressed by the activity of the earth worms. "It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures." He showed that in a single acre there were from 50,000 to 500,000 worms, each of which passed through its body some 20 ounces of earth a year. On two square yards studied by him the amount was 6.75 and 8.38 pounds or at the rate of 14½ to 18 tons per acre per year. Working their way through the earth the worms open roads for roots and rain. The soil passing through their bodies is softened and cast on the surface at a rate of some three inches in fifteen years. In Yorubaland in West Africa, Thomson estimates that every particle of the soil is brought to the surface once in twenty-seven years [1]. In as much as the bacteria demand an adequate supply of oxygen, it appears that they have been rendered a service by the worms. Ants and other insects are likewise plowing the soil. Elsewhere as in California observers have called attention to the labors of the hordes of ground squirrels, gophers, prairie dogs and similar animals as soil-builders. Plants thus may profit from the activities of animals as we shall see again later on.

Bacteria in Man

The rôle of bacteria as causes of disease is considered in another chapter. The digestive tract (particularly the lower intestines, for the acid conditions of the stomach are unfavorable to bacterial life) of all animals from the birds to man is densely populated by great numbers of bacteria from a few hours after birth until death. That they prosper there is shown by the fact that they are present in vastly greater numbers than in the food supplies eaten and they cannot be dislodged by starvation. Thirty trillions are said to be excreted daily by the human being.

> The alimentary canal of the infant is wholly free from microbes at birth, but within a very few hours thereafter invasion occurs. The first indication of a definite bacterial programme in the alimentary canal occurs about the third day of life. By this time the babe has settled down to a fairly definite life routine. The microbe change consists essentially in a replacement of the adventitious germs of the initial invasion by large numbers of lactic-acid-producing bacteria. . . . They prevent in no small degree the development of putrefactive and even disease-producing microbes.[2]

In similar vein Herter writes:

> There is not the least doubt that in some way—a rather intricate way—these normal and dominant flora of the intestine exert a protective action on the whole body. This protective action is complex in operation, but consists at least in part of a preëmptive effect on the intestinal domain, by which other types of bacteria are in large degree excluded. It is impossible to avoid introducing into the digestive tract many bacteria which would prove undesirable permanent tenants, and these are successfully discouraged by the motile biological activities of the more permanent and better adapted bacterial guests.[3]

Metchnikoff, one of the most brilliant biologists of the last generation, believed that the displacement of the native flora by "wild" types was a common cause of suffering and premature death. It was this belief which led to the emphasis on various brands of sour milk as valuable foods. Many still question the usefulness of the internal flora and believe it neutral rather than beneficial. Whether the animal profits or not, the arrangement is surely to the advantage of the bacteria.

Forms of Association

The wood of trees is eaten by few insects, as they do not seem to be able to digest the cellulose. The white ants or termites, however, feed freely on wood. It has been learned that they have in their digestive tract many little organisms of several varieties of flagellate protozoa. It has been found possible to kill off the flagellates by a change of oxygen pressure, the different sorts dying under different pressures. When the termites have been freed of the flagellates they starve if fed on wood. Let the flagellates be reintroduced and the termites prosper again. Not only do the flagellates do no harm to their hosts but they seem to be a positive benefit. There is reason to believe that this particular association has existed for vast periods of years.

The illustrations just given are described by the scientists under the title "symbiosis," in which the different organisms are occupying the same general place and may be thought of as "roommates," their relations being mutually advantageous, or at least neutral. A second sort of relationship where the partners feed at a common table and where they are "messmates" is called "commensalism," and a third type of association where one lives at the expense of the host is called "parasitism." Emphasis should be laid on the fact that we are here speaking of the relations between different forms of life, for the association of many individuals of one species in communities, such as the swarms of bees or herds of cattle, is of another order.

The difficulty of getting away from our man-centered interpretations is again apparent. The bacteria producing the nodules on the roots of legumes are in a sense parasitic and the nodules pathogenic, yet the final result is beneficial. The disease-producing bacteria are parasitic in man and he calls the results abnormal, but there is nothing abnormal about it from the standpoint of the bacteria. The accurate understanding and interpretation of many of the cases which will be found in nature is extremely hard and moral maxims based on natural phenomena are of questionable worth. Nature cares little for the hard and fast boundary lines which man is always trying to establish.

Symbiosis

In general, symbiosis implies a permanent association between two forms of life with "contrasting methods of feeding," as Lull says.

A form of Amoeba and many radiolarians among the Protozoa or unicellular animals, together with the fresh-water polyp, have numerous unicellular green plants, which live in the protoplasm of the animal. From the animal the plants receive protection and certain wastes, which they utilize as food. In return for this the animal receives oxygen, given off by the plants during the formation of starches.

But a still more remarkable instance lies in the lichens, which are compound plants formed by the intimate union of a fungus, which contributes to the partnership protection, attachment, and raw food materials, air, water, and nitrogenous salts, and a green alga, which elaborates the food. They can live alone, but the combination is much better fitted to withstand the vicissitudes of life than either would be singly.[4]

Commensalism

Commensalism is common.

Fishes are found in association with sea anemones, being in some way immune either to the sting or to the digestive juices of the creature within whose internal cavity they dwell. One fish dwells in amicable association with a sea cucumber, lying in the rectum of the latter, whence it darts out to secure its prey. A curious adaptation of the fish lies in the shifting forward of its own vent to a position beneath the throat, so that when it lies, as it often does, with its anterior portion protruding from its host the latter is not defiled by the voided waste of the fish. It is difficult to see what, if any, advantage is gained by the sea cucumber in this strange partnership, but it is not yet parasitism, because, so far as we know, no harm is done to the host. Another similar association is that of the remora, or sucking fish, and the shark. The former has an amazing modification of the dorsal fin into a broad, cellular, sucking disk on the top of the head, by means of which it adheres to the larger fish. A quick detachment is made when prey is sighted, and as quick a return when its hunger is satisfied. Here again the benefit to the shark or other towing fish is doubtful; as a matter of fact its speed must be markedly retarded. Whether it is a welcome guest and thus fills the need of companionship to the shark, or whether, like some well-meaning friends, it is merely "put up with," is by no means clear.[5]

Parasitism

Parasitism is so common and well known that illustrations are scarcely needed. One has but to recall the vast hosts of fleas, ticks, and mosquitoes, the invading armies of disease germs, the liver worms and tapeworms, to realize that all the higher forms of life are perennial hosts of parasites, many of which cause some harm and often kill the host. The "web of life" which nature has spun is so intricate that no one man may hope to understand it all.

REPOPULATION OF DEVASTATED AREAS

Once in a while we have a chance to see how nature starts anew to spin its web. The volcanic eruption at Kratakoa in 1883 covered two islands with hot ashes and stones, destroying all life. Three years later they were visited by the director of the botanic gardens of Java, M. Traub. "He made the remarkable discovery that the bare surface of the eruptive matter belched forth by the volcano was carpeted by a thin, slimy layer; it proved to consist of blue algae, which are coated with a viscous layer that easily retains water, and so already contributes to the disintegration, the breaking-up and weathering of the volcanic matter. At the same time the moist coating favored the development of fern-spores which were not slow to avail themselves of the chance. Both the blue algae and the fern-plants were blown across the sea as spores by the wind."[6] In time the islands will support much vegetation and the animals will find their way there again.

How Animals Serve Plants

In partial return to the vegetable world for the food it supplies to animals, the latter make contributions of no small value to plants. Probably the chief of these services is in the distribution of the pollen not only from one plant to another but also for many flowers where direct fertilization is impossible without the assistance of insects.

> More than two thousand years ago Herodotus observed a curious custom in Egypt. At a certain season of the year, the Egyptians went into the desert, cut off branches from the wild palms, and bringing them back to their gardens, waved them over the flowers of the date palm. Why they performed this ceremony they did not know; but they knew that if they neglected it, the date crop would be poor or wholly lost. Herodotus offers the quaint explanation that along with these branches there came from the desert certain flies possessed of a "vivific virtue" which somehow lent an exuberant fertility to the dates. But the true rationale of the incantation is now explained. Palm trees, like human beings, are male and female. The garden plants, the date bearers, were females; the desert plants were males; and the waving of the branches over the females meant the transference of the fertilizing pollen dust from the one to the other.[7]

In nature either wind or insects must carry the fertilizing pollen.

In the case of the red clover, bumblebees are the agents. Thomson in happy fashion enlarges one of Darwin's illustrations.

> "Plants and animals remote in the scale of nature are bound together by a web of complex relations. . . . I have also found that the visits of bees are necessary for the fertilization of some kinds of clover,—thus 100 heads of red clover produced 27,000

seeds, but the same number of protected heads produced not a single seed. Humble bees alone visit red clover, as other bees cannot reach the nectar. . . . We know that the red clover, importd to New Zealand did not bear fertile seeds till humble bees were also imported. The number of humble bees in any district depends in great measure on the number of field mice which destroy their combs and nests; and Colonel Newman, who has long attended to the habits of humble bees, believes that more than two-thirds of them are thus destroyed all over England." Now the number of mice is largely dependent, as every one knows, on the number of cats; and Colonel Newman says: "Near villages and small towns I have found the nests of humble bees more numerous than elsewhere and this I attribute to the number of cats that destroy the mice." Thus we may say with Darwin that next year's crop of purple clover is influenced by the number of humble bees in the district, which varies with the number of the field mice, that is to say with the number of cats.[8]

Commenting on Darwin's original observation Huxley humorously said that every one knew that the number of cats varied with the number of old maids. The amount of labor performed by the bees is enormous. A red clover blossom contains less than one-eighth grain of sugar. There are 7,000 grains in a pound. The bees must visit some 56,000 clover heads, each having some 60 florets, thus repeating the operation 3,360,000 times, to get a pound of honey.

Most of the pollenization is due to the chance contact of the insect. In some instances the insect deliberately moves the pollen for its own purposes and thus unwittingly brings it in contact with the pistils of the flower. This is the case with the yucca of our Southwest which depends solely upon the little yucca moth. The fig industry of California was made possible by the importation in 1900 of an insect which fertilizes the blossoms of the Smyrna figs.

Many animals besides man assist in the distribution of plants. Seeds are dropped by the birds along the fence rows. Squirrels bury many nuts which they fail to recover later and which may thus get a chance to grow. Burrs catch in the fur of passing animals and are transported over considerable distances. A similar service is also performed by the larger animals for the smaller. Minute mollusks attach themselves to the feet of birds and drop off in some new location which may or may not be favorable. If it is, a new colony is formed. Cattle transported from the Southwest carried the ticks which caused the dreaded Texas fever in the northern herds. The story of man's activity will be told in the next chapter.

Rate of Reproduction

In as much as the life of any given organism is limited, although the limits may vary from an hour for some bacteria to a couple of thousand years for some trees, nature has to provide some plan of reproduction if any species is to survive. As a whole the lowest forms of life multiply most rapidly. A cholera bacillus may divide every twenty minutes and might thus in one day become 5,000,000,000,000,000,000,000 with an estimated weight of 7,366 tons. An annual plant with only two seeds would be represented by 1,048,576 in twenty-one years. The female of the house fly lays 120 eggs and has twelve generations a season at Washington, D. C. It breeds chiefly in horse manure where it has been found at the rate of 1,200 to the pound. The descendants of a single pair between April and November might amount to 214,577,844,320,000,000,000,000, while the offspring of a pair of mosquitoes in 180 days would be represented by the figure 2 at the left of one of these lines followed by a full row of ciphers. A herring has been known to have 47,000 eggs, a 75-pound cod has 9,100,000 eggs and a giant ocean sunfish (Mola) is said to have contained 300,000,000 eggs. A pair of robins having four young each season, assuming that the descendants lived and reproduced at the same rate, would have 20,913,948,846 descendants at the end of twenty years. The entire present human race might have descended from a single pair starting at the year one of our own era.

Perhaps one of the most remarkable experiments that have thus far been carried out with the lower forms of life is that of Professor Woodruff of Yale, with the slipper animalcule, the protozoan *Paramecium.* Woodruff began his pedigreed culture from a wild individual on May 1, 1907. They reproduce by simple division about three times in forty-eight hours, so that by May, 1912, they had reached 2,945 generations, with a potential bulk of protoplasm ten thousand times that of the earth. And the individual is on the verge of invisibility! It has been further calculated that at the nine-thousandth generation—and they have passed that to-day, for they average some six hundred plus a year—the resultant protoplasmic mass would exceed the confines of our universe and would be extending into space with the rapidity of light.[9]

Now, in the actual world no such increase as indicated by any of the illustrations takes place. Yet every one knows that there is a most rapid increase at times. There is a vast difference in the number of flies in early spring and in the autumn. Eight male and seven female large-mouthed black bass were put by the Fish Commission in a pond at Washington, D. C., in May, 1892. At the end of November, 37,000 young measuring from 3 to 4 inches, and 500 weighing about a half pound each were removed.[10] It is evident that there is a rapid replacement of adults by the young and a seasonal, if not permanent, increase in the total number of any species. The total aggregate of life can neither be measured nor comprehended. A drop of sour milk may contain 40,000,000 bacteria. About all that we can do is to say that there appears to be as much life in every part of earth as existing conditions make possible, granting that conditions may change, and then try to discover the conditions.

THE BALANCE OF LIFE

The clew to the riddle lies in the fact that every organism requires food and, as already stated, in most instances this involves the destruction of other organisms. No organic product is known which is not eaten by some insect.

> If all the feeders on vegetable life were allowed to develop absolutely without check during two successive years, the first of them would see every green thing swept from the face of the earth, and the second would destroy all possibility of the recurrence of fully 90 per cent of all existing plants. . . . Under normal conditions, and in the long run, one pair of moths, producing say 500 eggs, are represented next year by another pair of the same species, and no more: that is, out of 500 eggs, producing 500 caterpillars, 498 are destroyed in some way. . . . The important thing is that a species abundant in number of specimens has become so in spite of the combination of all its natural checks and, conditions remaining equal, will maintain itself in the same ratio just as a rare species barely maintains itself against the combination opposing it.[11]

"It has been estimated that there are annually on our coast from New Jersey to Mononomy a thousand million blue fish averaging five or six pounds each. They eat or destroy ten fish a day or a total of ten billion fish a day—weight of 300,000,000 pounds. This takes no account of blue fish under three pounds of weight." [12] If this is a fair estimate of a single variety in a given area, who can visualize the total food consumption of all forms of life on earth? Recognizing that from the egg stage to death, and by no means stopping there, every organism is preyed on by some, not by all others about all we can say is that the survivors are those who have not yet been eaten.

Checks to Increase

There is, however, another check to the increase of organisms even where the food supply itself may be adequate. Changes, especially sudden changes, in the physical conditions destroy countless organisms. In the Chicago drainage canal just below the city, 1,200,000 bacteria per c.c. have been found, but 150 miles away there were only 3,700. While some of this decrease was doubtless due to the attacks of other forms of life, much was due to the effects of the exposure of sunlight. Early and late frosts destroy many insects. Flood and storm take their toll of plant and animal life, even of man himself. In the middle of February, I saw a killdeer, arrived from the south a month ahead of schedule time. Two days later came a big snow which still covers the ground. That bird is on his way to warmer climes or to destruction ere this.

A change in climatic conditions, an increase or decrease in the rainfall, a warmer or colder season may stimulate the growth of given forms of life which serve as food to others and bring about a disproportionate increase, or scarcity may force sudden migrations of free moving animals. Hence we hear of the enormous flight of locusts, as in Natal in 1893 when one swarm took twenty-one days to pass a given point, or in Mexico in 1924 where they ate every living crop on countless acres. The mice epidemics in Nevada in 1907 and in California during the winter of 1926-1927 will be long remembered. Such an increase inevitably attracts the enemies of the increased species until an equilibrium is again attained. "In this way it happens that after a season of grass-

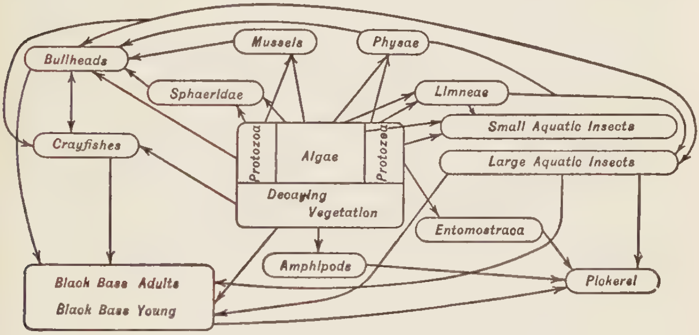

FIG. 3. FOOD RELATIONS OF AQUATIC ANIMALS

hopper abundance a season of blister-beetle abundance is almost certain to follow, and any abnormal increase of the former is almost sure to be checked by the corresponding increase of the latter."[13]

This interdependence of the various forms of life in any given area is well shown by the diagram in Figure 3.

> Let us assume that because of some unfavorable conditions in a pond during their breeding season the black bass decrease markedly. The pickerel, which devour young bass must now feed more extensively upon insects. The decreased number of black bass would relieve the drain upon the crayfishes, which are eaten by bass; crayfishes would accordingly increase and prey more heavily upon the aquatic insects. The combined attacks of pickerel and crayfishes would cause insects to decrease and the number of pickerel would fall away because of the decreased food supply. Meantime the bullheads, which are general feeders and which devour aquatic insects, might feed more extensively upon mollusks because of the decrease of the former, but would probably decrease also because of the falling off of their main article of diet. We may thus reasonably assume that the black bass would recover its number because of the decrease of pickerel and bullheads, the enemies of its young.[14]

The increase of any form of life may depend not only on the presence of some other type of life but upon different types at different stages of its existence. This is true of the fluke producing the liver rot of sheep:

> Each fluke produces half a million or more eggs which pass out of the sheep and fall to the ground. The rain washes them into pools and ponds where they hatch, giving forth an active conical creature, exceedingly small, which swims about until it finds a snail, into which it bores its way. Failing the discovery of a snail it perishes; but unfortunately nature provides plenty of snails for it. Within the snail it grows into a sort of sac which in its interior develops another type of young; within these last more young develop, some like the parent, and some like minute pollywogs which emerge from the snail and swim away, climb up a grass blade, lose their tails, and become inert. If

a sheep eats grass with these things clinging to it they come to life again, plod their way into the sheep's liver, and soon develop into full grown liver flukes.[15]

Comparable phenomena are very common, such as the white-pine blister rust which must pass one stage of its career on plants like the barberry, or the germ producing malaria in man which must live for a time in a mosquito of certain species.

The ichneumon fly (Pimpla) is parasitic on such moths as the army and orchard worms and the white-marked tussock moth, a great enemy of shade trees. It has its own parasites also.

When the tussock moth caterpillars appear in great numbers on our shade trees during a given season, it will almost invariably be found that this Pimpla is present also in great numbers and that the majority of the caterpillars are stung by it. This means that the following season there will be an unusual number of adults of the parasitic insect which is now termed the primary parasite. So great is this abundance that the first generation of tussock moth caterpillars is practically wiped out of existence. Then comes the second curious fact, that the secondary parasites become enormously abundant and kill off the abundant Pimplas. At the end of the same season or at the beginning of the next the tertiary parasites put in their appearance and the secondary parasites are destroyed, thus giving relief again to the primary parasites which once more begin to be abundant and ready for the next case of super-abundance of the host caterpillar.[16]

Food Habits

A summary of the food habits of organisms may be attempted. Plants feed chiefly on inorganic substances, many of which must have been prepared by bacteria. Plants are sometimes parasitic on other plants as well as on animals, as the mistletoe on the oak or the disease thrush on men. A few plants capture and devour insects. Insects are the commonest of all animal forms, their species far outnumbering all the others put together. Most of them feed on plants but many eat other insects and any other animal flesh that they can attack. The lower vertebrates feed largely on insects or other animal food. The birds are divided into insectivorous and the seed-eating, though many are omnivorous. The lower mammals are chiefly carnivorous. Higher groups are often wholly herbivorous though the primates are omnivorous. All animals, from insects and crustaceans to birds and mammals, contain parasites.

The Struggle for Existence

We are accustomed to think of "natural death" as the end of a wearing-out process continued through life, that is, we have a machine in mind. In fact, no form of death is less common. The usual cause of death is the attack of some other organism. Well may Roosevelt write:

> Civilized man now usually passes his life under conditions which eliminate the intensity of terror felt by his ancestors when death by violence was their normal end, and threatened them during every hour of the day and night. It is only in nightmares that the average dweller in civilized countries now undergoes the hideous terror which was the regular and frequent portion of his ages-vanished forefathers, and which is still an everyday incident in the lives of most wild creatures. . . .
>
> Death by violence, death by cold, death by starvation—these are the normal endings of the stately and beautiful creatures of the wilderness. The sentimentalists who prattle about the peaceful life of nature do not realize its utter mercilessness; although all they would have to do would be to look at the birds in the winter's woods, or even at the insects on a cold morning or cold evening.[17]

Mr. Roosevelt is entirely correct unless he wishes us to understand that the animals are not only frequently scared but have an abiding fear of death, in which case we should have to class him as a "nature-faker."

The desire to live results of necessity in what is called competition or the struggle for existence. It is the spectacular aspect of the daily round of life and is always in the foreground, attracting attention as does a fire or a fight. There is another aspect of life, however, which is quite as real and which may be of equal importance, though it is hard to compare the two for their ends are different. This second aspect grows out of coöperation in nature, and that organisms live in communities rather than as scattered individuals.

We are forced to interpret the associations of plants as due to chance rather than emotion of any sort. Nor would it be proper to assume that there is no competition in a community of plants. There are so many plants on many fields that they cannot grow and prosper as they would if half of them were removed. They compete for water, food, and sunlight. Some are killed by the competition, others just survive, some thrive but all survivors are handicapped. We can see nothing voluntary in the associations of a colony of coral polyps or oysters nor in the swarms of mosquitoes. It is not easy to tell where anything more than the chance location of birth begins to be dominant, but the ant and the bee have a form of social organization which cannot be interpreted on a basis of chance.

Animal Associations

Even in the animal associations we must not think that competition is eliminated. Insects have some habits that surprise us:

> Perhaps the strangest of these is a little fly, one of the gall-midges which as a grub is found beneath the bark of trees. The grubs of this gall-midge produce a number of young within their own bodies which immediately proceed to eat their mother, and when she is but a memory they bore out of her empty skin and start life on their own account. A swift retribution overtakes them, however; for their young appear within them and they are devoured in the same way. This process of progressive mother

> eating continues all the winter, and at the beginning of spring the now very numerous grubs transform into adults.[18]

The females of many spiders and of such insects as the praying mantis regularly devour their mates.

While it is true that some of the higher animals live in very small family groups like the gorilla, many of them seem to prefer the largest possible groupings. Wherever man is not abundant and food conditions are favorable, animals gather in enormous flocks.

> Even with the naked eye we could see hundreds of yellowish forms swimming in the desert mirage. Wild asses, without a doubt, but never before had I seen a herd so vast. They were massed in three dense groups on the valley floor, and for miles the horizon was dotted with stragglers. We counted a block of two hundred and could estimate fairly accurately that there were at least one thousand animals in the herd. Subsequently we learned that there were many more than that; for several hundred were below our sight in the bottom of a shallow ravine.[19]

Of the grassland antelope, Andrews reports:

> The greatest herd of antelope that I have ever seen. . . . Thousands upon thousands of bucks, does and fawns poured in a yellow flood over the rim and spread out like a vast fan upon the plain. . . . Perhaps fifty thousand were in the bottom of an enormous valley.[20]

> We saw across the river, on the horizon, a small yellow streak which seemed to be moving towards us. It looked exactly like a huge caterpillar creeping on the ground. We watched it intently. The yellow streak, little by little, grew in length and width until suddenly, in a second, it spread into a large spot, which, widening and widening on either side, still kept moving in our direction. It reminded me then of a swarm of locusts, such as one sees in South America, spreading over the fields after dropping to earth in a cloud from the sky.
>
> In a few minutes the yellow patch had grown to such a size that we realized, far as we were from it, that it covered many acres. After that we began to see in the mass of yellow hundreds

> and thousands of tiny dots which moved individually. Then we knew what it was. It was a great herd of reindeer, the Barren Land Caribou, migrating south.
>
> Spellbound, we remained beside our camp fire, watching probably the most stupendous sight of wild game in North America since the bygone days of the buffalo. . . .
>
> That column widened like a fan until it lost itself on either side of a swarm of caribou, so closely packed together that acres and acres of gray moss were completely hidden by their moving bodies. And the noise of their hoofs and the breathing of their lungs sounded like far-away thunder. . . . I started counting and reached three thousand. Then I gave it up. There were too many. . . . And for what seemed to us an eternity we were surrounded by a sea of caribou galloping madly inland.[21]

While North America was better provided with bird life than with quadrupeds it is hard to exaggerate the size of the herds of bison and antelope found on the western prairies within the memory of living men. The passenger pigeons moved in such flocks that they almost darkened the sun and broke the branches of the trees on which they settled. So rare a bird as the whistling swan has been seen in flocks estimated at a thousand since 1910. Some 60,000 black brant passed Prince Edward Island in the migration of 1909. Crows gather by thousands at their roosting places in winter.

It is evident that many of these associations are not accidental; others are. The killer whale hunts in small groups. Two coyotes frequently combine to chase the jack rabbit; pelicans have coöperated to drive a school of fish ahead of them. It is likewise clear that the habits of some birds in posting sentries while the main flock feeds or sleeps contributes to the safety of all and that there is often safety in numbers. It is easy to get illustrations of the care of the young not only by actual parents but frequently by older animals in no wise related to the adopted infants. That the parents will attack possible enemies as the kingbird does the crow even in the absence of young is equally true. It is common for the male to fight for the female, but it is more rare for him to lighten her duties by setting on the eggs. Somehow we do not like to find instances where the parents eat, destroy, or neglect their offspring in order to care for foster infants imposed upon them, yet, such there are. Many fish eat the young of their own species as the pig will do at times. Insects of the same brood frequently devour each other. The cuckoo bees which have no workers frequently take possession of the bumblebees' nest, killing their queen if necessary, and then proceed to permit the bumblebees to raise cuckoo bees only.

Insect Associations

The wonderful organization of the nests of ants has caught the attention of many students and has been described so often that only passing reference is here needed. Wasmann estimates that some two thousand species of animals are associated with the ants, some as guests, some as slaves, some as parasites. We have no idea why the ants tolerate the presence of most of them. We find the ants keeping the aphids from whom they appear to get a drop of liquid of which they are fond.

> Certain native ants even keep the eggs of plant lice within their nests during the winter. The sanguinary robber ant occupies herself almost exclusively with hunting and leaves the cultivation of plant lice to her slaves, these slaves being ants of a different species. The Amazon ant exists only by the capture of slaves and in that connection develops the most brilliant warrior talent that we know in the entire animal kingdom. Its mandibles are modified to be solely weapons for killing and are unsuited for domestic occupations; furthermore it has even lost the instinct for feeding by itself and must be fed out of the mouths of its slaves.[22]

In some of these cases the "coöperation" appears to be primarily for the advantage of the stronger party.

Mutual Aid

> Whether the feeling be fear, experienced at the appearance of a bird of prey, or a "fit of gladness," which bursts out when the animals are in good health and especially when young, or merely the desire of giving play to an excess of impressions and vital power—the necessity of communicating impressions, of playing, of chattering, or of simply feeling the proximity of other living kindred beings pervades Nature, and is as much as any other physiological function, a distinctive feature of life and impression ability. This need takes a higher development and attains a more beautiful expression in mammals, especially amid their young, and still more among the birds; but it pervades all Nature.[23]
>
> As seen from the above, the war of each against all is not the law of nature. Mutual aid is as much a law as mutual struggle.[24]

And again:

> "Don't compete—competition is always injurious to the species, and you have plenty of resources to avoid it." . . . That is the watch-word which comes to us from the bush, the forest, the river, the ocean. "Therefore combine—practice mutual aid.". . . That is what Nature teaches us, and that is what all those animals which have attained the highest positions in their respective classes have done.[25]

The message of Kropotkin is needed even though it may be a bit exaggerated. There is coöperation and mutual aid has its merits. The higher the animal the longer the period of infancy. Perhaps we shall best avoid confusion in our minds if we remember that competition and coöperation are but names for two processes, or two aspects of one process found everywhere in the organic world. From what standpoint is the moral quality of the process to be judged? If you reply, "From that of man," then we shall have to ask whether the process is beneficial or injurious to him. We may find it to be both. Competition may benefit him by lessening his enemies or injure him by destroying his friends. Mutual aid may do the same. Clearly, that which is needed is a complete understanding of the actual relations between the many forms of life in any area under discussion so that man may be in a position to evaluate the changes that he has made or is about to make. This is the theme of the next chapter.

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CHAPTER V

MAN, A DISTURBING FACTOR

Wee, sleekit, cow'rin', tim'rous beastie,
O what a panic's in thy breastie!
Thou need na start awa sae hasty,
Wi' bickering brattle!
I wad be laith to rin and chase thee
Wi' murd'ring pattle!

I'm truly sorry man's dominion
Has broken nature's social union,
And justifies that ill opinion
Which makes thee startle
At me, thy poor earth-born companion,
And fellow-mortal!

. . . . .

But, Mousie, thou art no thy lane
In proving foresight may be vain:
The best laid schemes o' mice and men
Gang aft a-gley,
And lea'e us nought but grief and pain,
For promised joy.

—BURNS

MAN UPSETS THE BALANCE OF NATURE

Actually as well as potentially the greatest threat to the maintenance of the "balance of nature" lies in the steady increase of the human population of earth and in the ever-widening scope of man's activities. Here, again, a paradox confronts us. Civilization depends upon the upset of this balance but the upset is a threat to the civilization itself. On what evidence does such a statement rest?

The Warfare of the Future

There is no reason to believe that man's appearance on this earth created any special commotion among the other animals. The big flesh-eaters such as the saber-toothed tiger probably welcomed him to their diet and smiled at his puny efforts at self-defense. In these early days man was hunted and doubtless lived in fear of the big beasts as is indicated by the reverence man now shows for the tiger in the countries where it still survives and where man treats his name with respect and usually addresses him as "Sir Tiger." Yet, as man developed and began to make inventions, he became the greatest foe of all the larger forms of life, until to-day he thinks himself the master of all. Still the old tradition survives and man considers as his dangerous enemies the larger forms of life, ignoring the menace to his welfare of the vast hosts of insects and lower animals insignificant as individuals but collectively of great power. His own triumph over the great cats should warn him of the danger of his outlook. To put the problem in more dramatic form, one may say that slowly and steadily the conditions are developing for the greatest warfare the earth has ever witnessed and on the outcome of which all later history will turn. This will be the war between man and insects, to use the names of the two most important armies, although every other organic nation will be involved. In fact, innumerable skirmishes have already taken place without conclusive result. No one can predict the outcome with any certainty. One side has the advantage of numbers and an active loyalty to be stopped only by death. The other side has the skill and the wealth but is handicapped by the number of its members who are too lazy or too proud to fight and who are likely to trust blindly either in the Lord or the politician. What are the causes of this inevitable conflict and how do they concern us?

Man's Increased Needs

It is easy to make a general statement of the situation. The increase in human population requires a greater supply of those plants and animals used by man as food, clothing, and as materials for his industry while at the same time man demands more room for his cities and roads, thus reducing by so much the area from which he may draw his supplies. Let us see what this involves.

In an earlier day man depended on the wild life about him but his numbers were small and the satisfaction of his needs caused but little disturbance. He developed the idea that all things were made for him, an idea which he has never lost, and which is the starting point of *his* problem, for it leads him to underestimate the importance of his activities on other forms of life and on this vast web of interrelationships of which he is a part, and not an outside spectator. As man grew in numbers and knowledge, if not in wisdom, his attacks on his sources of food, fuel, and clothing became greater and greater until he began to look about for relief. This relief he found either in the domestication of the better types of plants and animals and on which he came to depend more and more, or else he sought new areas of earth and began his migrations. In actual history the two have gone together. The first involved an increasing standardization of his supplies and less and less reliance on the medley of products offered by nature. The second involved the deliberate transfer of as many of his domesticated forms as possible that he might use them in the new environment and the, usually unconscious, transfer of the common pests of his household. Along with the horse and cow, the wheat and the clover, man has taken the rat, the louse, the fly, the flea, and a great group of internal parasites. Their distribution has become almost identical with that of man himself.

When he settled down in a new land he began to cut the forests and cultivate the fields. Of necessity this changed the balance of nature in the given area. Many native forms of life were driven out or destroyed or were compelled to find new homes and new sources of food. Perhaps the crops planted by man supplied the food but if so, man was immediately involved. Perchance the native forms were too many for the imported and quickly consumed them, or perhaps the accidental importations found no native enemies and became at once serious threats to man himself. All of these possibilities and many others have been realized more than once in man's history. That which needs emphasis is that every move of man starts a series of results in the organic world which cannot always be foreseen and which may not be at all to man's liking. As an organism man is under the same general laws as all other organisms, and unless his mastery includes control of himself, his activity may involve his own destruction—a fact which he hardly realizes as yet. Let us turn from the generalized picture to a consideration of some of the details, most of them drawn from North America.

Primitive American Fauna

When the white man came to this continent he found no large wild animals of which the Indians had any special fear. The European brought a traditional fear of wolves but he found the coyote a noisy beast whose howling often frightened him until he found that the coyote was much more afraid of man than man was of him. Even the larger and more savage timber wolf of the farther north, which was almost identical with the wolf of Europe, rarely attacked man in so far as the records show. That they followed him and scared him often is certain. Those powerful animals, the bears, are primarily vegetarians, and were not man hungry. Even the grizzly rarely attacks man, though it often trails him through the woods. The biggest cats, the puma and the lynx, as a rule avoided man. It is admitted that all of these animals were powerful enough to be dangerous antagonists of man and that they would fight if cornered, but man stood in no danger if he let them alone. The herbivorous elk and bison were equally dangerous if wounded. Throughout American history more men have been killed by "domesticated" bulls and stallions than by all the larger wild animals put together.

The eastern woods teemed with deer, raccoons, opossums, and squirrels; the streams with beaver and otter; the ponds with muskrat. The prairies were tenanted by multitudes of bison, deer and antelope of various sorts. In the arid regions were colonies of prairie dogs and occasional badgers. In the western woods were deer again, and many bears. Foxes, wolves, and various ground squirrels were almost universally abundant along with hedgehogs, weasels, minks and rabbits.

In bird life this continent was unusually well endowed from the turkey of the eastern woods, the various species of grouse, and the innumerable hosts of geese, cranes, ducks and other wild fowl down to the smallest humming bird. Man had no fear of the birds, though a wounded crane was no mean antagonist.

The ocean and the streams abounded with many sorts of edible fish. In some of the early labor contracts of southeastern Pennsylvania and neighboring states it was stipulated that the workers would not be served with such common food as shad or canvasback duck more than once or twice a week. The salmon was the commonest of the eastern shore fishes, from the Delaware north.

Depletion of Food Supplies

It is now 1928 and the white man has pushed his way over the continent. What is the present situation? The large animals of the sea have been so generally destroyed that whaling is almost a lost art. Big specimens of any of the larger fish are seldom found. The big turtles as well as the terrapin are almost exhausted. The salmon began to disappear on the Atlantic coast early in the nineteenth century. In 1798, a 16-foot dam was built at Miller's River about 100 miles from the mouth of the Connecticut. The salmon remained common for two or three years below the dam but after ten years they had disappeared. This is but a sample. The salmon fisheries on the Pacific coast gave indications of decline. Some scapegoat was needed and in Alaska it was decided that the bald eagle was responsible. In fact the eagle rarely catches an active salmon but has fed for ages on the dying adults. So in 1917 the legislature put a bounty on each eagle. Down to August 4, 1927, bounty had been paid on 40,753 eagles and many more must have been killed but not recovered. No concrete evidence was offered that spawning salmon had been destroyed. Bulletin No. 27 of the Biological Survey states: "All things considered the bald eagle is rather more beneficial than otherwise." Some one ought to start a movement to replace the bald eagle on our national emblem by the turkey buzzard. In California where the eagles are not so numerous the fishermen began in 1925 to kill the white pelican for similar reasons. In 1919 in Florida the brown pelican was cleared of the same charge by an investigating committee. The one obvious cause, man, seems to occur to no one. The shad was the most important river fish of the central Atlantic states. In spite of the fact that it is very prolific, it decreased steadily until about 1870 when, through the activities of the Bureau of Fisheries and the artificial stocking of many streams, it began to increase again. Since 1900 it seems to have greatly decreased again. Excessive fishing coupled with the pollution of the waters by sewage and chemicals have wrought havoc with the fish. It is claimed that there are now about 100,000 miles of streams in Pennsylvania alone, all of the water being unfit for human consumption and 95,000 miles containing no fish of value. The same story holds for terrapin, oysters, mussels and lobsters.

Extermination of Reptiles

The white man came with an admitted fear of the snakes. Here he found in fact four dangerous sorts, of several varieties. The copperhead of the eastern states, the moccasin of the southern streams, the coral snake of Florida, and the rattlesnake which ranged from New England to California save in the higher altitudes, were all poisonous. Their actual danger will be apparent to the reader if he will make a list of all persons known to have been killed by them.

The rattlesnake is almost extinct in the north Atlantic states and west to Nebraska. It is still common in the lower parts of the Rocky Mountain country and in most of the South. It is a sluggish snake, gives warning, and coils before striking as a rule, and then cannot strike for more than half its length, so that the real danger to man is small. The copperhead is sometimes found on the Palisades of the Hudson in New York, in the mountains of Pennsylvania and elsewhere. It is rare in heavily settled country but is always dangerous. The moccasin is found along the streams of the South where it is fairly common. The coral snake of Florida is the only form ever likely to be touched deliberately by man. Its local distribution limits any possible danger. Here might be mentioned our largest lizard whose bite is said to be poisonous, the gila monster of the river valleys of the hot and arid Southwest. Let it be granted that all poisonous snakes should be killed wherever found. They play a useful rôle in part but cannot be tolerated in settled communities where there are children, and are never agreeable bedfellows for adults (as the accounts of Lawrence in Arabia and Andrews in Mongolia show). Brazil, where there are a number of very poisonous snakes which are attracted to the plantations from the heavy woods by the presence of smaller animals on which they prey, has a much larger problem. There some 20,000 persons are bitten each year and 5,000 die. In India from 40,000 to 50,000 deaths are reported yearly as due to snake bites.[1] Evidently the East Indian refusal to kill the snakes is very foolish. Equally foolish, however, is our failure to discriminate between the poisonous and non-poisonous varieties, for the latter are among the best friends of the farmer. The smaller species live largely on insects, the larger upon mice and other small game. Yet, we kill the garter snake and the black snake almost as quickly as the dangerous sorts. But the black snake is harmless and is the deadly enemy of the rattlesnake which it kills whenever it meets it.

Destruction of Bird Life

One has but to read any account of conditions in Colonial days and compare it with what he knows of to-day to realize the slaughter of bird life which has gone on almost without cessation. While man trapped and netted many birds in early days and occasionally wrought havoc in some densely populated colony during the nesting season, the birds were not seriously harmed until the invention of the shotgun. Then man began to kill for food, later for decoration, finally to use any flying bird as a target going on the general principle that the larger birds were the easiest target. Contributing to the final result, a reduction in bird life, has been the destruction of breeding sites by cultivation of the fields, the cutting of forests and the draining of marshy places. The vast hordes of wild fowl, migrating twice a year across the continent, appeal to the imagination. To-day but a handful of these hordes are left. The canvasback duck is rare and when served in high-priced restaurants is usually the redhead. The Labrador duck was extinct by 1875. The wood duck, one of the most beautiful forms, is very scarce. What man of this generation has seen swans migrating across the United States? Some are left, to be sure, though the trumpeter swan is at the door of extinction. What else can we expect when we read of the killing of 5,000 American coot on the opening day of the gun clubs in Merced County, California, alone? The official records of Louisiana for the year 1909-1910 record the killing of some 6,000,000 game birds, of which over one-half were ducks and over one-sixth were bobwhites.

The destruction is not limited to what we call game birds for of the 1,100 odd species of North America not more than 200 could be classified as having any food value; nor is it limited to the United States. The last living specimen of the great auk was seen in 1852 and the Pallas cormorant disappeared at about this time. The Guadeloupe parrot, Gosse's macaw of Jamaica, the Cuban tricolored macaw are gone. Gone too is the pretty little Carolina parrakeet which inhabited the southeastern quarter of the United States, save as it survives in captivity. The Eskimo curlew was last seen in Nebraska in 1911. Almost gone is the heath hen of Nantucket, the eastern form of the prairie chicken. This latter once gathered by the hundreds in a flock in Iowa and Dakota though now it is far from common. The other grouse have decreased as has the bobwhite. Almost gone are the golden, the black-bellied, and the upland plovers, the whooping and the sand-hill cranes.

For years fashion decreed the wearing of aigrets, the plumes of the white egret of the far South. Yet, the securing of these meant the killing of birds in the nesting season and the destruction of the young. To a large extent the terns have gone from the Atlantic coast for much the same reason.

During the latter part of the nineteenth century as many as 55,000,000 birds were slaughtered for millinery purposes in the United States in a year. Forty thousand terns were killed yearly on Muskeget Island and one man on Long Island is said to have killed 11,000 in a season. From this island 70,000 tern skins were sent to New York City in four months.

There were 4,000,000 humming-bird skins in one shipment from South America. As a result, the arctic tern was driven from New England, and the least and roseate terns nearly exterminated. The public conscience was finally aroused and after some ineffective legislation the traffic in skins was stopped by the Lacey Law of 1900. Canada passed similar laws in 1914 and Great Britain in 1921. Before 1920 an increase in the terns was noted on the north Atlantic coast and in time they may become common again.[2]

The most striking illustration is the extinction of the passenger pigeon, once so common that the early accounts read like fiction. A single flight was estimated to contain 2,230,272,000 birds. The last known wild bird was killed in Michigan in 1908 and the last one in captivity died in the Cincinnati Zoölogical Garden, September 1, 1914. In 1869 this bird was shipped from Hartford, Michigan, to the extent of three carloads a day for forty days, a total of 11,880,000 birds.

In the East the game birds are about gone but on the Pacific coast the slaughter continues. Now the eastern hunters (sportsmen?) are turning to smaller fry and robins, blackbirds, meadowlark, bobolink and doves are being shot as "game." Robins are hunted at their roosting places as in Texas where reports tell of the killing of 10,157 in two hours and ten minutes by seven men. A quarter of a million are said to be killed in Louisiana yearly for food. If these birds are shot, by no stretch of imagination can their food value equal the cost of the ammunition.

Destruction of Animals

The story of the animals is very similar. The armies of squirrel of which Audubon tells are nowhere to be seen. The groundhog, the coon and the opossum survive in decreased numbers. The fox is still here largely because some folks want to ride horses and keep packs of hounds. The beaver has been driven to the wilderness. The antelope is gone from the plains. Our game laws are not respected. Even during the closed season deer are often killed as "mountain lamb." The bison, often killed for their tongues alone, the bodies being allowed to rot, are hardly more than a memory, though we are preserving enough to keep the memory alive. Save where man for some reason has given them protection the larger mammals have almost disappeared. Again, what else could we expect? A trade paper states that in a single season, 1924-1925, the following pelts appeared in the market, the actual total, as estimated, being 20,000,000, not including rabbit:

Muskrat	8,000,000
Skunk	2,000,000
Opossum	1,500,000
Coon	500,000
Mink	450,000
Weasel	300,000
Red fox	150,000
Marten	100,000
Gray fox	50,000
Wolf	50,000
	13,100,000

Hornaday states that the Eskimos with high-powered rifles have exterminated the musk ox within the last fifty years until not one is left in 1,500 square miles where once they were abundant. All over the earth the large wild animals are disappearing and extinction is not far off unless man stops the process. There is no dispute as to the facts. How are they to be interpreted?

Regret as we may the shrinkage in the number of animals on earth it must be admitted that much of this is unavoidable. As man clears the fields he destroys the coverts which shelter many animals. Elsewhere he fences the plains over which they roam, and interferes with their migrations. In any case man cannot conduct agriculture if hordes of large animals are roaming about and likely to feed in his fields and gardens. What sort of fence will stop an elephant or rhinoceros in Africa? What would a Nebraska farmer do if a million bison decided to harvest his crop? Even the Jersey farmer has suffered in recent years from the attacks of the Virginia deer which have increased under protection. There seems to be but one answer. If we wish to preserve the larger mammals they must be limited to certain areas set apart as preserves, as the Yellowstone Park, where man does not seek to earn his living by farming.

It should be noted also that the keeping of domestic animals is in part a substitution of forms most useful to man for others of little immediate use. There are no bison on western ranges but there are many sheep and cattle as well as horses.

Benefits of the Upset

The evidence thus far presented substantiates the claim that man has been upsetting the balance of nature. We may be sure that nature will make her own readjustments but we must ask what effect they will have on man? To avoid dispute let us admit that the actions of man have been for his own immediate benefit but it does not follow that the ultimate effects will be beneficial. Let us survey the field from the standpoint of man.

Problems of the Food Supply

The basic human activity is the getting of food. This may be secured in three ways: (1) fishing and hunting, (2) stock-raising, and (3) agriculture. Fishing remains an important industry but civilized man hunts for sport and not for food. For most people, only the second and third methods are involved, and agriculture is by far the more important. For present purposes we may omit further reference to fishing and hunting.

Protecting Domestic Animals

The raising of domestic stock involves their protection against enemies. Whereas man had little to fear from the wild animals in America he found them a menace to his stock. Even as late as 1915 it was estimated that each wolf and puma was killing $1,000 of livestock yearly; each coyote and bobcat about $50; and every bear that had developed the stock-killing habit about $500 worth. The total loss was between twenty and thirty million dollars yearly. The president of the State Agricultural College of New Mexico in 1917 reported that 34,350 cattle, 165,000 sheep and 850 horses had been killed in a year in that state by predatory animals, the loss being some $2,715,250.

The damage done by individual animals is surprising. One wolf in Colorado killed $3,000 worth of cattle in a year. Two Texas wolves killed 72 sheep in two weeks. A wolf in New Mexico killed 25 cattle in two months and another killed 150 cattle in six months. Three coyotes in Utah killed $500 worth of sheep in an hour. A bobcat in Texas killed in a month on one ranch 54 sheep and one goat. A grizzly bear in New Mexico killed 50 cattle in one year and had killed 32 ere taken the next year. "The Custer Wolf" in South Dakota is thought to have killed $25,000 worth of cattle in six or seven years.

About 1915 the national government began the use of trained hunters to destroy the predatory animals and some 125,000 animals were killed within five years (109,000 being coyotes). In the year ending 1920 some 50,000 animals were killed, thus saving live stock valued at some $6,000,000.[3] It will be noted that these depredations are almost wholly west of the Missouri River.

Protecting Poultry

The poultry-grower finds his chief troubles in the attacks of smaller animals, rats, weasels, skunks, foxes; and certain of the birds, crows, owls, and hawks. Some animals, often including the dog, are fond of eggs as are the jays and crows, and even the chickens themselves. Egg loss may be prevented by frequent collection of eggs and by providing good nests. Old chickens are seldom molested, although the skunk or mink getting at sleeping birds will sometimes do great damage and there is nothing that Reddy Fox likes better than a fat hen. If protected sleeping quarters are provided the aggregate loss will be small. Young chickens are attacked by many enemies. This loss is most easily prevented by giving them protected runs. If the grower allows all the chicks to roam freely he must expect considerable loss. Not infrequently he fails to recognize his animal friends and enemies. He neglects his flocks, allows rats to live unmolested about his buildings and then blames every hawk and owl for the loss of his poultry. The great horned owl will take chickens but it is not common, hunts at night only, and seemingly, never invades a chicken house. A rare winter visitant, the snowy owl, and possibly the barred owl, might prey on chickens. The smaller owls feed chiefly on insects, mice and other small fry and are valuable friends of the farmer. The large hawks, commonly called "hen hawks," almost never try to catch chickens. Certain of the falcon type, the duck hawk, Cooper's hawk, the sharp-shinned hawk, feed largely on birds and are always willing to include young chickens in their diet. The duck hawk will winter sometimes in the heart of our large cities and live on pigeons. There is no excuse for confusing this type of hawk with the useful sorts like the sparrow hawk which lives largely on rodents. The damage they do is really in the destruction of bird friends of man.

> It is no longer the fashion to call the red-tailed and red-shouldered hawks poultry thieves. They are now recognized, like the sparrow-hawk, as birds to be courted, not killed. Poultry make up but 1 per cent of the food of a red-shouldered hawk and ten for the red-tailed species. The screech-owl, barn-owl and long- and short-eared owls are given every inducement to remain in the neighborhood of farms. The American sparrow-hawk devours hundreds of insects and field mice to every song bird it takes. For each bird of economic value consumed, the owls, with the sole exception of the great-horned variety, destroy an average of 400 small rodents; two or three are devoured at a meal. Quite different are these records from that of the sharp-shinned hawk, which lives on a diet 98 per cent bird.[4]

The Department of Agriculture has examined some 50,000 stomachs of hawks and owls and finds only six of the seventy-five species and varieties deserving of condemnation (goshawk, duck hawk, pigeon hawk, Cooper's hawk, sharp-shinned hawk, horned owl).

Pennsylvania at one time put a bounty of fifty cents on each hawk or owl killed and allowed twenty-five cents additional to the official making the affidavit on the ground that the poultry of the state was being killed by them. In eighteen months some $90,000 was paid out of the treasury. If we estimate that 5,000 chickens might have been killed during this period (though this is a gross exaggeration) and give them a value of twenty-five cents each, the total loss would have been $1,875. If, however, we estimate the harm done by the mice, etc., that these birds would have killed, at two cents each, then these birds were worth $30 each to the state for the period. The number of birds killed was 128,571, so the state taxed itself some $3,857,130 plus the bounty paid, $90,000, a total of $3,947,130 to offset an estimated damage of $1,875. The mice increased so fast that the folly of the law soon became apparent and it was repealed.[5] Ohio had a similar experience.

Control of Weeds

The increasing dependence of man upon agriculture both as regards food and clothing gives added importance to its problems. The chief antagonists to man are weeds and insects, while the rodents are far from negligible.

Weeds are but plants which man does not use or are useful plants growing in fields reserved for other crops. In the South, Johnson grass is a very valuable fodder but if it starts in a field of cotton it is very difficult to eradicate. Weeds, then, may compete with cultivated plants for the water and food of the soil and thus reduce the yield. They may grow so rank that they smother out the desired plants. Man must move his strawberry beds both because the strawberry plants get too thick and, chiefly, because weeds take possession. The weed seed may be harvested with the grain and reduce its value, as the cockle in the wheat, making it less desirable for food and spreading the weed pest if it is used as seed. It is very difficult to get seed free from weeds. Hence, man is often planting the very thing he desires to destroy. Weeds growing beside a field may offer harbor for plant diseases or for insects which feed on the crops. Thus man must wage constant warfare against undesirable plants.

In spite of man's recognition of this weed nuisance, he has carried it with him from country to country. Our lawns are infested with dandelion and plantain brought over from Europe. The Canada thistle, one of our most pestiferous weeds in the East and Middle West is supposed to have been brought from Russia along with the seed of wheat and to have reached us in the same way. Our grass fields are often ruined by daisies and docks of various sorts and sometimes plants poisonous to stock are introduced. The elimination of weeds is both costly and tedious. It is not an easy matter to kill a burdock, for example.

Insects the Great Enemy

Insects are far more difficult to control than weeds. Not only have they a considerable power of movement but man also assists in their distribution. When America was settled, most of the cultivated plants were introduced into an area in which they found few native enemies at first. Yet as early as 1770 in Connecticut the army worm damaged grain crops to such an extent that a local writer said: "Had it not been for the pumpkins which were exceedingly abundant, and potatoes, the people would have suffered greatly for food. As it was, great privation was felt on account of the loss of grain."[6]

In parts of the Middle West when the fields were cultivated a new food supply was offered to the grasshoppers, crickets, and other native forms which came in vast multitudes to eat the crops. The damage done to crops by the western grasshopper from 1874 to 1876 was estimated at $200,000,000.

The stronger winged grasshoppers were able to fly

> hundred of miles from the Rocky Mountains to the Mississippi Valley, alighting first where cultivated land begins. Thus Kansas, Nebraska and the Dakotas were preëminently sufferers from grasshopper invasions, and not infrequently conditions were sufficiently good there to permit the insects to lay their eggs, providing for a brood which the year following destroyed the vegetation while still unfledged, and then migrated yet further east to do destructive work as adults and to perish gradually, in the egg stage, in the moist unsuitable soil. . . . No one who has not seen grasshoppers in this Western country can form any real idea of their actual abundance, and their destructiveness has been the theme of many a writer. . . . Conditions now are much better than they were and can never again be quite as bad. A large area of what was one time ideal breeding ground, is now irrigated and under cultivation, and the enormous belt of alfalfa and other crops now basing the foothills, checks and takes up the migrating hordes that occasionally start from the uncultivated areas. The march of advancing civilization

spells the doom of some of these grasshopper species, as it has that of many another animal.[7]

So too, the Colorado potato beetle, a native of Mexico, spread throughout the East and made its way to Europe. Gradually plant enemies were imported until our agriculturists everywhere have to fight the insects. A few of the more important of present pests will illustrate the problem. While the insects are the great enemies of man, probably not more than 5 per cent of them do directly any great harm to the farmer.

Cotton Boll Weevil

In 1894 there appeared in the southern counties of Texas a little beetle-like insect known as the boll weevil. It takes but fourteen days to develop from egg to adult and the progeny of a single pair may reach 134,000,000 in a season. It attracted little attention at first but nevertheless continued to spread at a rate of some 50 miles a year. It lays its eggs in the unripe cotton bolls which are eaten as the insect develops. It hibernates in the stalks of cotton or other plants. By 1912 it had crossed the Mississippi River and by 1921 had reached every cotton-growing section. The destructiveness of this weevil may be shown by the record for seven counties in Mississippi, which produced 171,190 bales of cotton in 1907. The production in 1909 was 89,577 bales; in 1910, 61,432; in 1911, 37,816; and in 1912, 30,909. The loss caused by this one insect is almost beyond calculation. In some areas it has made cotton growing almost impossible. The cost of fighting it has been tremendous and it has caused an almost complete revolution in methods of cotton culture. Other nations have been seeking new cotton-growing areas lest the world's supply be cut off. The little ant which holds it in subjection in its native haunts cannot survive in this country, and no local enemy has been found equal to the situation. The seriousness of the situation is not altered by the fact that in 1926 we raised the largest cotton crop on record.

Corn Borer

While some fifty insects attack corn and reduce the yield some 10 per cent, the most dangerous of all seems to be the European corn borer, discovered in New York about 1917. There is evidence that it was imported about 1909 on broom corn from Hungary. It is now found from Pennsylvania to Ontario, and as far west as Indiana. In the most heavily infested areas it has caused an almost total loss of the corn crop. Who can estimate what it may do if it reaches the center of the corn-growing areas in large numbers? Up to the present the only remedy seems to be the cutting of the corn stalks close to the ground and then destroying them by burning. While this may be effective it will greatly add to the cost of production. In 1927 the government spent ten million dollars on a campaign covering two and a half million acres. Ninety per cent of the borers were destroyed but the end is not yet.

Japanese Beetle

In 1916 at Riverton, New Jersey, it was discovered that a pretty little beetle, now called the Japanese beetle, was doing serious damage to crops. This beetle appears to have been imported on iris plants by a local nursery about 1912. It did not cross the Delaware until 1920, but has now spread from the District of Columbia to Stamford, Connecticut, about 6,000 square miles about its starting point being heavily infected. It eats almost everything and any one who has seen its ravages does not think this an overstatement. The most rigid quarantine on movement of plants has not stopped its spread and poisons have been of little avail. I am told that the nursery most involved has spent not less than $30,000 a year in fighting it. The present yearly cost to state and national governments is not less than $800,000. Because of its habits it may prove to be the most dangerous pest as yet imported. Luckily certain wasps feed on the grubs and the adults are preyed on by some parasitic flies so that its increase may be checked. No immediate relief is in sight and no one can estimate the damage that may be done ere a balance is struck. "Lawns, golf courses, shade trees, gardens and farms have been utterly ruined by the beetle. Ripening fruit, leaves and bark of orchard trees have been eaten, leaving only the naked trees and fruit pits."[8] Meantime the experts have found two other beetles also from Japan whose future career is problematical.

Gypsy Moth

Two of the most serious pests that have appeared in New England are the gypsy and brown-tailed moths, both from Europe. In 1868 or 1869 an entomologist near Boston was experimenting with gypsy moths hoping to find a cocoon of commercial value. A storm set free some of the moths. The experimenter realized the danger and asked aid but was laughed at by his neighbors. Twenty years later the shade trees of the state were threatened and the legislature was aroused. Over a million dollars was expended and the moths were almost exterminated. Then the warfare stopped until in 1906 it was found that a large area was infested. About the first of August the wingless female crawls to some sheltered spot on a tree and lays masses of eggs. These are easily seen during the winter. If not destroyed they hatch in May and the young begin to eat the leaves. To-day nearly all the shade trees are protected by great bands of sticky material to prevent the ascent of the female. After scouring the earth some thirty enemies were found and many of them imported. A tachina fly from Japan has been probably the most helpful. At times the government has had to prohibit the movement of stone from the quarries as egg masses have been found on the rocks. The brown-tail moth also first appeared near Boston and has spread widely in New England. It too is an enemy of the shade trees. The female lays its eggs on a leaf in July. They soon hatch and begin feeding. The gypsy moth campaign costs us some $700,000 yearly.

Scale Insects

On the Pacific coast the scale insects have attracted the most attention. The San Jose scale was discovered in 1879, having been introduced on fruit stock from Asia. It consists of a minute shield fastened on to the bark as by a pin. It increases so rapidly that in a short time an entire limb may be coated. It is spread from tree to tree by the birds. Thanks to them and to the commerce in nursery stock it was distributed over the United States in a generation. At first it threatened to destroy our fruit trees as well as roses and other ornamentals. It can be controlled by sprays but, luckily for us, a number of parasites have appeared which are the chief factors in holding it in check to-day, although it may still do much damage in given areas. The orange and lemon trees were threatened by the fluted scale. In Australia this scale was kept in check by an insect known as the ladybird, "a small, reddish-brown, convex beetle, which breeds with marvelous rapidity and which, with voracious appetite and at the same time with discriminating taste, devours scale after scale, but eats fluted scales only, and does not destroy other insects." These were introduced into California and within five years the fluted scale menace was no more. Now a supply of these ladybirds is bred to meet emergencies.

These insects just mentioned are by no means the only ones we have imported which have done us harm. The commonest clothes, fur and carpet moths came to us from Europe. The flour moth is a great pest to the millers of Europe, Asia and America and is of uncertain origin, being attributed generally to some other country. The bee moth from Europe is an enemy of the apiarists. Our sugar cane is attacked by a borer from the West Indies which has been a curse since 1855 at least. The oyster-shell scale was in this country by 1794. The gall midge which destroys the seed of the white clover was first noticed in 1879. In our buildings are found the German cockroach (the Croton bug), the Australian and Asiatic as well as native varieties. There are over three thousand varieties of insects in other countries which would be harmful should they find their way here and it is evident that there are more ways than we have thought. The bedbug and body lice have traveled with man and the Argentine ant now infesting the houses in parts of California is not much more welcome. In revenge we sent Europe the grape phylloxera which threatened to destroy the vineyards.

Crop Damage by Insects

In addition to the damage done by these imported varieties must be added the work of native species. The codling moth seriously reduces our apple crop. The chinch bug attacks our corn and wheat. In 1897 the white-pine butterflies were so thick in Idaho that "they hung in ropes from the limbs to the ground, and drove people out of the huckleberry patches, and even springs and pools had to be skimmed before one could get a drink of water." They "practically stripped the pines." In the last ten years the lodge-pole pines, over 6 inches in diameter, and one-half of the yellow pines of Montana have been killed by beetles. From 1910 to 1920 the spruce-bud worm in Maine killed 75 per cent of the balsam and 50 per cent of the spruce.[9] The total damage done to our crops runs into hundreds of millions of dollars a year. The white termites do immense damage to the wood in our buildings in the warmer parts of the country. Some of the minute crustaceans, like the so-called "sow bugs," which most folks class as insects, should not be forgotten. To this we must add the injury to wharves and piles done by the teredo and other animals and must remember that the fuel cost of our steamers increases about 1 per cent a month after they leave the dry dock, due to the growth of barnacles. To this immense total we shall have to add the cost of attacks on our domestic animals by insects. As if the total were not large enough already, we are reminded that the parasitic diseases of plants and animals of which we are taking no account in this chapter must also be added.

METHODS OF ATTACK ON ENEMY INSECTS

It is evident that man's desire to protect his plants and animals involves enormous costs. In as much as the insects are the chief rivals of man for the food and clothing produced, it is they who cause much of the cost. We may fight them directly by poisons, even using, as we are now doing, airplanes to scatter poison over large areas of land, but there may come a time when this direct attack is too costly or even impossible for reasons purely physical. We are driven, then, to ask if there is any way of making an indirect attack which may be equally effective and less costly. Two possibilities suggest themselves, birds and parasitic insects which will destroy the harmful types.

The use of parasitic insects has been shown in some of the cases just given. There is no doubt that in the future much greater use will be made of this method. Indeed, our experts are now scouring the world to discover natural enemies of harmful types. Yet the danger is ever present that helpful types introduced into a new environment may prove harmful rather than the reverse.

Birds and Man

The services of the birds to man deserve further consideration, especially in view of the wholesale destruction of bird life which has been mentioned. Clearly little direct harm to man has been caused by the birds. On the other hand, they have helped him in many ways. Man has highly prized the fertilizer (guano) collected from the colonies, particularly in arid regions. Such birds as the herons have helped him by eating the crayfishes and crabs which have often injured or destroyed his levees by digging holes through which the water might pass. Scavengers like the vultures and gulls have destroyed dead animals which would have been offensive or dangerous. In so far as food choice is concerned, we may roughly divide the birds into seed-eaters and insect-eaters, freely recognizing that most birds eat both to some extent. Later we shall consider their relation to harmful rodents.

Bird Census of the United States

It is estimated that about four million birds breed in the United States each year. To this number must be added those which pass through the country in their migrations and the number which come from the north to winter here.

In a survey made in the northeastern part of the country by the Department of Agriculture about ten years ago, there were found for each hundred robins about 83 English sparrows, 49 catbirds, 37 brown thrashers, 28 house wrens, 27 kingbirds and 26 bluebirds.

> The census covered 58 of the 108 acres of the average farm of the Northeastern States and revealed on this area a bird population of 69 nesting pairs, and on the remaining 50 acres it is estimated that there would be about one pair to the acre; in all, 114 nesting pairs to the 108 acres of farmed land. On the 46 acres of wild land existing for each 108 acres of farmed land it is safe to assume that there would be fewer birds than on the census covered area.

Heavy forests contain relatively few birds. In an Idaho forest 254 pairs were found on 768 acres.

> An approximate average of one pair of birds to each acre of farm land was found, but individual censuses show that

it is possible, under strictly farm conditions, very largely to increase this number. Near Wellington, Va., a tract of 49 acres of a diary farm, of rather less than the average of plowed land, supported a bird population of 137 pairs, or three pairs to the acre. . . . Near Albany, Mo., 80 acres was divided into 14 acres of plowed land, 27 acres of hayfields, a brushy pasture, with a little heavy timber along the banks of a small stream, and the customary farm-yard, orchard, garden, etc. The conditions for bird life were probably more favorable than the average, but not sufficiently different to account for the 298 pairs of birds nesting on the tract.[10]

Birds as Seed-Eaters

On a Maryland farm studied by the Department, 645 birds were killed to discover what they had eaten. About one-fifth of all food eaten was seeds. In some individual cases these formed from 50 to 70 per cent of the food. The daily consumption per acre was about 46,000 seeds or more than one to the square foot. At least one-seventh of all our birds are primarily seed-eaters. The finches and the sparrows have a diet in which weed seeds form 75 per cent. The proven record of the bobwhite is amazing, over 126,000 seeds in one day. Bobwhite is known to eat 129 different seeds. "In Bulletin No. 21, Biological Survey, it is calculated that if in Virginia and North Carolina there are four bobwhites to every square mile, and if each bird consumes one ounce of seed per day, the total destruction to weed seeds from September 1st to April 30th in those states alone will be 1341 tons." [11] The little tree sparrow winters in Iowa in great numbers. Beal once estimated that, on a basis of ten to the square mile, some 875 tons of weed seed were eaten in a season by this bird alone. A fair breakfast for a mourning dove is put at 3,000 grass seeds and it is estimated to eat 7,000 seeds a day. There can be no question that birds have a pronounced effect on the increase of many plants. No one objects to their eating all the weed seeds possible, but man's feeling is changed if they eat grain or fruit. Common sense tells us that birds which have always eaten wild fruit will not hesitate to take cultivated fruit if the native plants are destroyed and replaced by cultivated forms. We may protect the fruit by killing the birds, as often happens, or we may use our wits and try to offer some more acceptable fruit. Birds will leave the cherry tree to eat the mulberries, which are insipid to man, and often prefer cherries of little use to man to the finest varieties. Why not plant some of the varieties preferred by birds? Where birds gather in large flocks the damage to an orchard may be real but elsewhere the actual harm is seldom great. The farmer who is unwilling to give a few meals of fruit in return for what the bird does for him is a poor business man.

Birds as Grain-Eaters

It must be admitted that cultivated grain is often eaten by birds. Again, save where there are large flocks, the actual damage is not excessive. A flock of passenger pigeons in the old days would have left little grain in a field. The crow likes grain and even sprouting corn, but not infrequently he is after the cut worm at the base of the corn. Only thirty-eight of the birds shot on the Maryland farm had eaten grain and this formed only 1¼ per cent of the food eaten. Bobolinks eat a good deal of grain in the South. About 85 per cent of the food of the English sparrow is grain. The blackbirds and grouse eat some grain. It should not be forgotten that the ripe grain is seldom left in the field for any length of time, hence the damage done by birds is sharply limited.

Birds as Insect-Eaters

Under ordinary conditions the damage done to field crops and fruits is more than compensated for by the destruction of insect life. Practically all birds eat insects. About one-third of the food eaten by the birds shot on the farm just mentioned consisted of insects, 27 per cent of which were harmful to the crops and 4 per cent beneficial. The stomachs of 855 bluebirds were examined and it was found that 68 per cent of the food was insects. Of this, beetles formed 21 per cent; grasshoppers 22 per cent; caterpillars 10 per cent. Harmful insects formed over 90 per cent of the insect diet. In late summer grasshoppers formed over half of the total diet. Forty-two per cent of the robin's food is animal matter, chiefly insects, over one-third of them noxious. Forty-two per cent of the diet was of wild fruits, no less than sixty-five species being identified. The domestic fruits averaged less than 8 per cent being limited to the early small fruits. The brown thrasher has a diet of 41 per cent animal food, chiefly insects; small fruits like raspberries 8 per cent, and grain 3 per cent. The catbird eats insects for 44 per cent of its food and does much more good than harm. Nearly one-third of the food of the blackbird is of insects. In the spring it often follows the plow and feeds heavily on grub worms. It eats some fruit and 45 per cent of its yearly food is grain. Much of the grain eaten is waste but the bird in large flocks does some harm to the standing grain. During the breeding season it feeds almost wholly on insects. The orioles are specially fond of caterpillars, and are the most active enemies of the cotton boll weevil. Seventy-four per cent of the food of the meadow lark is of insects, crickets and grasshoppers being preferred. In the South it takes the cotton boll weevil and in Utah the alfalfa weevil. It is a species of great help to man. Kingbirds, pewees, and nighthawks feed largely on insects. The woodpeckers attack types of insects rarely secured by the other birds. The stomach of a yellow-billed cuckoo contained 250 tent caterpillars; another contained 217 fall webworms. Even bobwhite, whose fondness for seeds has been shown, makes one-sixth of its diet of insects, particularly in late summer.[12]

The English sparrow is said to have a fondness for the seventeen-year locust, and eats the brown-tailed moth at times. Practically every insect enemy of our chief crops is eaten by some of our common birds. How much does this mean to man?

Insect Parasites

The entomologist admits the food habits of birds, but claims that it is easy to overestimate their value owing to the fact that many of the insects are infested with parasites which would destroy them anyway. It is impossible for the bird to know or distinguish the healthy from the parasitized forms and the destruction of the latter is not a service to man. The bird-lover admits the validity of the criticism and admits that some insects eaten are helpful rather than harmful. He points out, however, that the parasites usually destroy the host after it has eaten and done its damage whereas the bird stops the harm at once. It seems that the final verdict will be that man needs the help of the birds as well as of friendly insects.

Rodent Pests

Taking all things into consideration, the greatest warm-blooded enemies of man in America are the rodents, both native and imported. The Department of Agriculture estimates the harm they do at not less than $500,000,000 yearly. Ten years ago the crop yields of many western farms were being reduced from 10 to 30 per cent by the attacks of prairie dogs, squirrels, gophers and jack rabbits. The government undertook a very extensive campaign and the pests have been reduced on many millions of acres. On a range of 90,000 acres in Arizona, the result has been an increase of grass great enough to feed some 4,500 extra head of stock. Native rodents are estimated to cause a loss of $150,000,000 yearly in our crops and to destroy forage on pasture range of equal value. In one Virginia county the pine mice damaged orchard trees to the extent of $200,000 in two years. Pocket gophers in Idaho in 1919 caused a break in a water canal which cost the company $5,000 in repairs and destroyed 25 per cent of the hay crop on 30,000 acres.[13] In an Iowa nursery over 3,000 trees were girdled in one season by rabbits; and in a Maryland nursery 2,000 out of 4,000 trees were ruined.

Mice

Mice are responsible for a loss of $3,000,000 yearly in the United States. Short-tailed field mice appeared on the Humboldt River in Nevada in 1907 and by November there were from 8,000 to 12,000 per acre. During the summer they ruined one-third of the alfalfa, totally destroying many fields, 15,000 out of 20,000 acres having to be replanted. They destroyed three-fourths of the potatoes, badly damaged the remainder and severely injured the beets and carrots. They girdled and killed most of the young shade trees planted along the irrigation ditches and about the fields. A conservative estimate of the losses in this district was $250,000. Nature started to even the account by collecting some 2,000 predacious birds (hawks, owls, gulls, crows, ravens and herons) and 1,000 carnivorous mammals (skunks, weasels and badgers) which ate some 45,000 mice a day or 1,350,000 a month. The mice had increased rapidly for a couple of years. Then came the plague and then a sudden decrease for which the animals mentioned and some disease probably were the chief factors.[14]

Rats

The rats, of which the common brown rat is the most important, cause a loss of not less than $200,000,000 yearly, it being estimated that there are as many rats as men in the United States and that each rat causes a loss of some $2.00 yearly.

The constant labor of an army of more than 200,000 men is required to produce the materials eaten and destroyed by rats. If half this loss were represented by grain destroyed, it would take about 5,000,000 acres to produce it. In 1908 the Biological Survey made a careful study of rat infestations in two cities, Washington and Baltimore, with the result that the actual losses of produce and other property amounting annually to $400,000 and $700,000, respectively, were revealed. These sums are nearly in ratio to the populations. The Women's Municipal League of Boston recently announced that losses from rats in that city amounted to $1,350,000 each year. Losses in Pittsburgh, Pa., have been estimated at over $1,000,000 a year.[15]

Furthermore, rats are one of the most important agencies in the distribution of such diseases as the bubonic plague. Quite in contrast to the above stands the record of the bats which are insectivorous and of great value to man in his fight against his enemies.

Certain of our hawks and owls feed on rodents. In late fall and winter the sparrow hawk feeds largely on meadow and house mice. The staple food of the long-eared owl is meadow mice. Three-fourths of the diet of the screech owl is mice. Nearly 9 per cent of the food of nestling crows is of rodents, rabbits being preferred, and the adult crow eats them as well. Most of these birds deserve to be protected rather than destroyed by man simply because they do some damage.

DIFFICULTIES OF PEST CONTROL

Effects of Bird Destruction

Enough evidence has been offered to demonstrate that the wholesale killing of birds is likely to have very disastrous consequences for man himself. It is doubtful if man can carry on agriculture profitably without the assistance of birds in the face of insect competition. Years ago Forbush estimated that the destruction of bird life in this country had already imposed a burden equal to $1.67 a year per acre of cultivated ground. How serious this is may be seen when we recall that the total tax collected on typical Illinois farm lands for the year 1926 was only $1.50 per acre, yet the farmer was complaining. It is admitted that some birds have probably increased in numbers. This is obviously true of the English sparrow. It appears to be true of the robin in many places. As the Middle West was settled and trees were planted in the towns, an increase of bird life was noted. Some species have enjoyed the protection offered by man and some have profited by the killing off of their own enemies by man. The point is that man must count the cost and not kill indiscriminately lest he injure himself.

The same argument holds as to his attitude towards many of the smaller mammals. The opossum seems to have extended its range since the white man came, but there is evidence that its numbers are declining. This is true of the coon and the skunk. While these all feed to some extent on man's crops they also destroy vast numbers of insects and mice. Thus they more than repay man for the amount they eat.

The suggestion has been made already that man may try in the future to utilize helpful forms of life in his contest with his enemies. In some instances this has been tried and the results have not been too satisfactory.

Unsatisfactory Remedies

Troubled by the ravages of the spring canker worm on the shade trees, the directors of the Brooklyn Institute introduced a few pairs of English sparrows in 1850. These did not thrive and later others were introduced. These throve as did others brought to other places. They saved the shade trees but then forgot to commit suicide and began to increase until as Hornaday says: "It is a national sorrow almost too great to be endured." The bird has spread into almost every corner of our country, often driving the native birds out of the towns. As noted, it is now the second most common bird in the northeastern states. It is noisy, quarrelsome and dirty, preferring grain to weeds and in towns has fed largely on refuse grain. It will eat some insects and may prove to be valuable later on. There seems to have been a stopping of the increase about 1912. Another bird of somewhat doubtful value is the European starling, first liberated in New York City in 1890. It is spreading rapidly over the East and winters in great flocks in Pennsylvania and Delaware. It has proven a menace to the fruit crop in Australia. Much to their credit both the sparrow and the starling eat the Japanese beetle.

In 1872 the mongoose, which in its East Indian home feeds on rats and snakes and is often kept as a pet, was introduced into Barbados and Jamaica to get rid of the rats which were injuring the sugar cane. The attempt was only too successful. The mongoose began to attack all forms of ground life and everywhere became a scourge.

> The most noticeable result . . . was not a diminution in the numbers of the rats, but a marked decrease in the numbers of the small doves and other ground nesting birds and of the lizards, coupled with a great increase in the numbers of obnoxious insects. For instance on St. Lucia the screw-worm flies soon became abundant and a terrible pest to live stock. Why? Because these flies, which like to sun themselves on rocks and fence rails, fall an easy prey to the numerous small lizards which frequent just such situations, and the mongoose feeds largely upon these little lizards.[16]

Owing to the reduction of the birds Jamaica is having trouble with ticks introduced from Mexico. Meantime the mongoose has reached other Caribbean Islands, including Porto Rico and Santo Domingo. Our government is greatly worried lest it find its way here and the importation is carefully regulated. Yet one was found in the Middle West a couple of years ago.

Rabbits

The English introduced the rabbit into Australia about 1860. Lacking local enemies, it increased so rapidly that, as in New Zealand, it became a question whether the colonists should not move out rather than try to fight it. It became necessary to build rabbit-proof fences and a few years ago over 100,000 miles of such fence was in use, observers stating that the grass often grew tall on one side of the fence whereas the other was almost barren. Partial compensation has been found in the shipment of rabbit skins to Europe, the number from New Zealand even before the war had reached a total of 12,000,000. During the war, rabbits were exported as food, owing to the meat shortage in England. The frozen, dressed rabbits exported in 1919 totaled 1,372,869.

Cats

In eastern America the domestic cat dumped by the wayside by some "kind-hearted" person or deserted by its owners has often gone wild and has become one of the serious enemies of native birds.

Disease

The story of man's warfare against disease is reserved for a later chapter. Here we must note, however, the fact that insects are of importance to man as hosts or carriers of some of the worst diseases of man and his domestic plants and animals. The mosquito is the carrier of malaria and yellow fever. The flea transmits the bubonic plague. The house fly helps to spread typhoid. Man helps to spread these dread enemies by the development of his commerce. He carried the mosquito infected with yellow fever in his ships just as he carried the rats infected with bubonic plague. Mosquitoes travel on his trains. Various insects ride in his automobiles to fall off and start centers of infestation. Likewise man carries plant diseases such as the fungus, which has destroyed practically all the "spreading chestnut" trees of the East, which seems to have come in some unknown way from Asia.

Needless Slaughter

The great difficulty which man faces in the impending conflict with the lower world lies primarily in his own ignorance and his unwillingness to sacrifice immediate advantage for the sake of ultimate gain. The ignorance may be removed by a better system of education, for all naturalists are agreed on the essential facts, but the masses of the people do not know them. Perhaps it is lack of imagination which leads the city dweller to tear up flowering plants by the roots only to throw them away in an hour or so when they wilt. Does this explain the habit of killing every strange animal encountered by the automobilist who has taken a gun (for self-defense?) on his trip? Does this explain the fondness for "mountain veal" which leads the natives to kill the deer out of season? Granted a knowledge of the facts, it is not easy to determine the best methods of preventing the harm that man does himself by his interference in the organic world. Only experience can reveal these. Shall the crow be killed by the thousands as a powder company has advised in recent years and as residents of New Jersey were doing in February of 1927? Can the importation of dangerous insects be stopped by an embargo on daffodils and other bulbs in accordance with the present policy of the Department of Agriculture? These are practical questions of great importance which cannot be discussed here.

Bird Protection

It is worthy of note that our attitude towards nature is being modified as our knowledge grows, and that gives us great hope for the future. We have stopped the traffic in bird skins which threatened to exterminate many species of birds. The national government began in 1913 to take over the control of all migratory birds and to determine the conditions under which they may be killed and sold, thus sup-

Birds, Largely or Wholly Extinct in America[19]

Species	States Once Inhabited	Extinct Now in	Now Inhabits
Passenger pigeon .	40	all	none
Carolina parrakeet.	30	all	none
Labrador duck	Atlantic Coast	all	none
Great auk	N. Atlantic Coast	all	none
Flamingo	Gulf States	all	West Indies
Roseate spoonbill .	Gulf States	all	West Indies
Scarlet ibis	Gulf States	all	West Indies
Ivory-billed woodpecker	25	23	possibly 2 states
Pileated woodpecker	30	24	26 states (very rare)
Whooping crane ..	35	33	possibly 2 states
Sand-hill crane ...	25	19	6 states (very rare)
Eskimo curlew .	30	all	none
Long-billed curlew.	35	21	14 states (very rare)
Snowy egret	40	29	11 states (rare)
Heath hen	New England States	all except	1 (Massachusetts preserve)
Wild turkey	40	10	23 states (rare)
Upland plover	Atlantic Coast and Middle West	17	rare elsewhere
Trumpeter swan ..	generally	7	very rare everywhere
Wood duck	generally	5	rare
Ruffed grouse	generally	3	usually rare

Fifteen other birds have been exterminated in one or more states.

planting the inadequate and conflicting regulations of the various states. Mrs. Russell Sage gave Marsh Island in the Gulf of Mexico, as a bird refuge, to the government. Certain lakes and breeding grounds are being set aside for the benefit of the birds and shooting is prohibited in the national parks. The black-bellied and golden plover were added in 1926 to the list of birds permanently protected, and Johnson and Sand Islands, 500 miles south of Hawaii, were made bird preserves. Private individuals and clubs have joined in the movement, which is by no means limited to our own country. The future of the other animals is largely in the hands of man. Can he develop an adequate sense of his responsibility and devise proper methods to maintain a balance in nature which will be to his advantage? On the answer to this question turns his own future as well.

Man versus Insects

If he fails in this attempt then it may well be that the insects will ultimately win and the dismal picture painted by Holland become a reality.

> When the moon shall have faded out from the sky, and the sun shall shine at noonday a dull cherry-red, and the seas shall be frozen over, and the ice-cap shall have crept downward to the equator from either pole, and no keels shall cut the waters, nor wheels turn in mills, when all cities shall long have been dead and crumbled into dust, and all life shall be on the very last verge of extinction on this globe; then on a bit of lichen, growing on the bald rocks beside the eternal snows of Panama, shall be seated a tiny insect, preening its antennae in the glow of a worn-out sun, representing the sole survival of animal life on this our earth—a melancholy "bug."[17]

Insect Societies

But in spite of all the regressive characters which we have mentioned as characterizing the social individual one may admit that the societies, considering each as a whole, are powerful agents, compared to any solitary, non-social, individual. The only dangerous rivals of the social species, then, are other social species. They constitute in effect the most virulent forces of the entire fauna, since they are capable of destroying each other as well as the solitary species about them, whether by contest or by theft. We must expect that the social species by their activities, unless checked by external factors, climatic or other, will ultimately bring about the extermination of the solitary species and the survival of a small number of very powerful and very prolific social species. It is hardly necessary to call attention to human activity from this viewpoint. Having exterminated about all the primitive human societies, and nearly all the mammals, save the races which he has domesticated, he has now undertaken the destruction of almost everything left alive on the planet. And the social insects assume the same rôle among the arthropods of earth, especially in the tropics, where their preponderance is absolute and where they have not yet come in contact with civilized man.

It is to be foreseen that with the progress of civilization, man will exterminate the terrestrial fauna and flora, excepting that which may be of profit to himself. But the most prolific and ingenious ants will remain as his rivals and his plague, and, without doubt, will be among the insects which are the last to disappear. And in this struggle with the ants, man will everywhere triumph, thanks to the indirect methods, that is to say, by modifying or suppressing the external conditions on which their existence depends.[18]

Summary

The upset of the balance of nature, necessarily involved in the growth of the human race, is fraught with danger both to man and to other organisms. Increasing attention must be given to this topic lest the problems grow unduly. Man's ultimate supremacy is probable, though far from certain. His greatest rivals, as Wheeler states, will be the social insects and his control will come not by frontal attack but by the use of indirect methods.

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PART II

MAN IN CONTROL OF NATURE

CHAPTER VI

DOMESTIC PLANTS AND ANIMALS

Still will the seeds, tho' chosen with toilsome pains,
Degenerate, if man's industrious hand
Cull not each year the largest and the best.
'Tis thus, by destiny, all things decay
And retrograde, with motion unperceived.
—VIRGIL

Roughly speaking, there are about as many domestic animals on earth as there are human beings. This statement omits all pets as well as birds and insects. The total is made up as follows: Cattle, 432,630,000; horses, 105,400,000; asses and mules, 20,000,000; swine, 162,000,000; goats, 117,200,000; sheep, 588,000,000. These comprise 1,416,030,000. To the number we must add the buffalo, carabao, elephants, camels and reindeer whose distribution is limited. The reader must turn to some good geography to get an adequate picture of their location for their distribution varies even within a given country.

Such a table as that on page 152 is misleading unless the unequal areas of the different countries, their stage of civilization, and the use made of the animals are kept in mind. While India has one-fourth of the cattle of the world it has but ten per square mile as compared with one hundred in Germany and one hundred and sixty in Holland. Uruguay has eight cattle to the inhabitant as compared to two persons per cow in the United States. Since cattle are sacred in India neither their flesh nor milk is eaten to any extent nor are they exported but are used, together with the buffalo, as draft animals and beasts of burden. In our own country there are large cattle ranches where condensed milk is used and no cows kept for milk; while the Pennsylvania farmers often sell their butter fats and use oleo for the table.

DOMESTIC ANIMALS OF THE WORLD[1]

(*Figures show percentages in different countries.*)

Country	Horses	Mules and Asses	Cattle	Swine	Sheep	Goats
Argentina	9	4	7	2	13	4
Australia	2	..	..	..	13	..
Austria-Hungary .	4	..	4	9	..	..
Canada	3	..	..	2	..	..
Denmark	..	..	..	2	..	..
East Africa	..	..	..	..	..	3
Egypt	..	4	..	..	..	..
France	5	..	3	4	..	..
Germany	4	..	5	16	..	..
India	..	8	25	..	5	..
Italy	..	6	..	..	..	..
Mexico	..	..	..	..	..	4
Russia	33	..	12	10	13	..
Spain	..	9	..	..	..	..
Turkey, Asiatic ..	..	12	..	..	7	8
Turkey, European.	..	9	..	..	3	10
Un. of So. Africa	..	..	..	..	5	10
United Kingdom...	..	..	3	2	4	..
Uruguay	..	..	..	..	4	..
United States	23	24	14	37	8	..
All Others	19	24	27	16	25	33

DOMESTICATION OF ANIMALS

The early history of the domestication of animals is almost unknown. We do not know the time nor the place of the first taming of any of the more important species. Moreover, the animals have varied so much under domestication, and have been crossed so much with related forms both tame and wild, that the determination of the wild originals is extremely difficult, so difficult that Darwin doubted if it could ever be done. Most of the larger mammals were well represented in Europe, Asia and North Africa and the earliest domestication might, therefore, have been in any of the three. Since the oldest civilizations were located about the eastern end of the Mediterranean it is there, naturally, that the earliest records are found. It is noteworthy that not a single animal of special importance has been added to the domestic list in the last two thousand years in spite of the vast extension of the area of animal culture.

Cattle

The first domestic cattle appeared at least 6000 years B.C. They are found in the Swiss lake dwellings of early neolithic times. These cattle were of slender build and short horns, the uneven forehead narrow between the horns but wide between the large eyes. This is still the dominant type of Asia Minor and North Africa and is represented in Europe and America by the Jersey. The wild original is unknown. Keller derives it from the banteng but Antonius rejects the evidence and prefers to believe that there was a small and perhaps more localized form of the Aurochs.

The aurochs (*Bos primigenius*) of several closely related races was widely distributed from Africa, through Asia and Europe to Spain. Under the name of "rimu" it was hunted by the Assyrians and Job asked if man could make it stand at his crib and cultivate his field. It survived wild in South Germany until the Middle Ages, until 1400 in East Prussia and until about 1627 in a herd near Warsaw. This was a large animal with long horns. When and where it was domesticated we do not know though it seems to have been outside of Europe, as it was known to the Hamites of Egypt. Turkestan seems to have been an early distribution center and later the Balkan states. Possibly it spread to Europe through Crete and the other Ægean centers of the Minoan culture from 2000 to 1300 B.C. The Ur type is represented to-day by many of the cattle of eastern Europe as well as Italy, the fighting strains of Spain, the Galloways of Scotland and the Longhorns of England. It is also found among the Hereros and Hottentots of South Africa. As a domesticated animal in Europe it dates from the end of the neolithic period. Antonius derives the zebu type of cattle from some variety of the Aurochs even though India is the present center of their culture, and believes that it spread through Africa in relatively recent times. Several varieties of Asiatic buffalo were domesticated at a date later than that of the cow. These domestic forms differ from the wild types by possessing more slender forms and smaller horns. The yak of Tibet reminds us of the Ur in so far as horns are concerned. The tame forms are much smaller and the color more varied. The wild type of the banteng was found in Java and neighboring islands. The wild form of the gayal ranged from India to Burma and was probably the largest of the buffalo. These animals have been of great value in Asia.

Horses

The horse was brought under domestication much later than the cow, not earlier than 2500 B.C. in so far as is now known. The legislation of Hammurabi makes no mention of large domestic animals, but the horse is referred to in a letter dating perhaps between 1945 and 1902 B.C., and it is known that at about this time there were invasions by northern hordes. The oldest reference from Greece dates from about 1700 B.C. The horse first appears as a war animal. By 1580 B.C. it was known in Egypt under the Hyksos. In the Tel-Armana period, 1400 B.C., the horse was brought in as booty. The Hittites in the fourteenth century had no true cavalry and this was true of the Assyrians until 700 B.C. By 100 B.C. Diodorus speaks of the Arabian type of horse. In Europe there is no trace of the horse until the late neolithic period when scattered specimens seem to have appeared in the northeast, at a time corresponding to the copper culture of central Europe, again not before the middle of the third millennium B.C.

Two species of wild horses at least (very possibly more) ranged over much of Europe and Asia. The first to be domesticated, and the only type of Europe during the bronze period, was a short-nosed and rather slender horse known as the oriental horse, to which the wild Russian form, the tarpan, belonged. This survives in the only wild horse of to-day, the Przewalski's horse of the desert of Gobi. This was the ancestor of the horses known to us as Arabian. It spread east as well as west and reached southern China. Antonius believes that the Mongols domesticated a variety (called *Equus ferus* by him) which they carried to north China by perhaps 2200 B.C. and which the Huns brought later to Europe. After this tarpan type was domesticated the heavy forest horse of Europe (*Equus robustus*) was somewhere tamed or else there were crosses between the tarpan and the forest types. This seems to have been the origin of the northern ponies and the horses of the Romans which were larger than those of Greece. The Romans reported the presence of the forest type in Spain. This heavy, calm horse became the ancestor of the draft horses, such as the Clydesdales of England and the Percherons of France. It seems to have been domesticated before the Roman era, the oldest known center being Bohemia. The Berber type of North Africa was taken to Spain and thence to England.

Wild asses were formerly common in Asia and Egypt and the ass was domesticated by the end of the bronze period, first, as now appears, by the Hamites of Egypt. It came early to Europe but was used in agriculture only along the Mediterranean where it is still important.

Mules appeared as soon as the horse culture came into the lands possessing the ass. They appear in Asia but were scarcely known in Egypt. The Greeks used mules to some extent, not breeding them but importing them from Asia Minor.

Camels

Wild camels were widespread in Asia at an early period, reaching even to Europe. Wild dromedaries are entirely unknown either in ancient or later times. Yet the hybrid of the dromedary and the two-humped Bactrian camel seems to be uniformly unfertile. This indicates that they have been derived from two wild species. If so, we may guess that the Bactrian type came from the northeastern part of Asia and the dromedary from the southeastern. This domestication may have been as early as 2000 B.C. There is evidence of the existence of Bactrian camels in Mesopotamia by about 1000 B.C. Herodotus said that the Arabs had camels but did not mention their presence among the Egyptians and Libyans. Antonius suggests that there may have been no great development of camel culture until Islam began its spread. The Huns did not have camels.

Sheep

The domestic sheep appeared in Europe not later than 4000 B.C., possibly a thousand years earlier, and is best known from the Swiss lake dwellings of the developing neolithic era. This sheep seems not to have been a native of Europe and a Sumerian votive tablet of 3000 B.C. pictures a local sheep apparently identical. This was a small sheep with long tail and scanty wool; both sexes had horns. This type survives to-day in some places. Towards the end of the neolithic period (3000 B.C.) there appeared in Europe, along with the first use of copper, a much heavier sheep with larger horns and shorter tails, the so-called "copper sheep" which is generally considered a domesticated form of European sheep of the mouflon type. The earlier sheep seems to have come from Asia. The center of sheep distribution appears to have been in the higher regions of Asia whence they spread to Europe as well as America. There is no evidence of their presence in Africa until introduced by man. The copper sheep was the dominant form in south and middle Europe throughout the bronze and early iron periods. Through the crossing of these two types have arisen the various European races of later years. Nearer Asia seems to have been the original home of the fat-tailed sheep which has spread so widely in Africa.

Goats

The domestic goat appears in Europe at about the same time as the sheep and later becomes even more common. Its original center of distribution seems to have been in Asia somewhat to the southeast of that of the sheep. Our information as to the type of the earliest domestic goats of Europe is scanty. The horns of the first known were not particularly spiral. Later on appears a goat with much curved horns which may have been introduced by the same culture which brought in the copper sheep. The oldest herd of this variety seems to have been in Bosnia. Those of Mesopotamia and Africa were of different racial origin. There is evidence that the present goats can be traced back to at least three wild species. Goats have been more used in Africa than sheep, largely because they could withstand harder conditions. They and the pig are the only domestic animals of real value to the forest-dwelling African tribes.

Elephants

Little seems to be known of the history of the domestic elephant. The African elephant has never been domesticated. The Asiatic species was tamed and has been locally of great value.

Swine

Swine differ from the other animals just mentioned in that it is not easy to drive them great distances, hence they are never kept or prized by nomadic peoples. Their presence, then, is one indication of a relatively permanent settlement and a local origin from which the spread is very gradual until modern methods of transportation are available. Antonius suggests that the taboo of swine as food was not due to health considerations but to this contempt of free-roving peoples for the smaller domestic animals which they could not use.

The oldest domestic swine of central Europe, which appear in the remains of the middle neolithic period, differed so widely in their shortened and widened head and jaws from the wild boars that a foreign origin was long accepted. More recent researches have shown races of somewhat similar characters and this earlier judgment has been changed. Antonius says:

> We may consider our domestic swine as a purely European product. Whether here was the only or even the first center of domestication is another question. It was not the only center, for East Asia offers a site of swine culture of hoary antiquity. Whether this was older or younger than the European culture must remain an open question.
>
> We may accept with entire confidence the existence of three domestic herds; one in the Baltic region; a second south or southeast of the Alps and a third in eastern Asia.[2]

At least two European species lie back of our present varieties and at least one in Asia. As with the other domestic animals, these have been interbred from very ancient times. It is possible that a few individuals of foreign races have been introduced. Whether the pigs of North and Central Africa represent a local domestication or are the descendants of introduced stock awaits further investigation.

Reindeer

The reindeer of the moss-covered northern regions of Europe and Asia have long been in captivity and have proved their value to the natives. Why the American counterpart of this animal, the caribou, has not been domesticated by the Eskimo offers an interesting problem. The 1,280 reindeer introduced into Alaska between 1892 and 1902 have become of considerable economic significance, as they had increased to some 350,000 by 1927 and over a million had been killed for food or clothing.

Dogs

The dog is beyond any question the oldest of domesticated animals. One might say that the only question is whether man domesticated the dog or whether the dog attached himself to man and helped in the domestication of the latter. Admittedly he has been the most faithful and beloved of all man's companions, tolerant of neglect yet responding to care. From the paleolithic period on he has been with man and has varied so much under domestication that the problem of his origin is almost insoluble. His bones are found in the kitchen middens of Denmark as well as in the Swiss lake dwellings. On many of the earliest pieces of sculpture he is portrayed in such fashion as to indicate the presence of several varieties. The mummified forms of the dogs of the Peruvian Incas so closely resemble the remains of Europe that they would be identified with them if found in Europe. Did the ancestors of the Indians take the dog with them on their migrations? Are we to explain the contrast in size from the miniature lapdogs to the Great Danes as indications of different origins as well as of mixing of blood or have we to do with giant and dwarf types such as we often see among human beings? The two types of dwarfs found among men seem to be present in the dog world.

Formerly it was thought that the fox was one of the ancestors of the dog, but, doglike as they are, this seems not to have been the case for dog and fox do not cross. From present indications it would seem that some of the smaller wolves were first domesticated and that these have been crossed both by accident and design with larger wolves as well as, in some cases, with jackals, to produce the various breeds. Antonius believes that the dingo of Australia and some of the lowest types of the pariah dogs of Asia may well indicate the type that accompanied man in his migration into Europe. The earliest domestic dogs of Europe of which we have record are small dogs on the order of the terriers and the type is quite uniform, no marked variations being found until the end of the old stone age. By the end of the neolithic period came the large dogs of the mastiff type. Keller believes that the shepherd dog is descended from the Indian wolf. "It is easily demonstrated that the original home of the great 'dogge' is to be found in the highlands of Thibet. They became established in Europe at the time of Alexander the Great, and appeared in our Northern Alps at the begining of the first century, where they were distributed by the Romans." [3] Keller claims that the greyhounds are descendants of the Abyssinian wolf and had reached Crete by 2000 B.C. They were pictured on the coins of Crete and were exported to Greece.

Cats

One of the latest of the animals to be brought under domestication was the cat. The Nubian cat of the Nile Valley was portrayed on the monuments of the Egyptians before 2000 B.C. and was domesticated before 1300 B.C. It is pictured in Crete about 1500 B.C. The cat was not common outside of Egypt until the latter days of the Roman Empire. Greece and Rome, although troubled by mice, whose name indicates a thief, portray the weasel as their enemy rather than the cat. The latter reached Rome about the fourth century of our era and was in north Europe about the sixth century. Some writers would have us believe that the cat became more valuable in Europe after the arrival of the common gray rat from Asia and gained in esteem after the arrival of the more savage brown rat early in the eighteenth century. The cats of to-day, however, are not great rat-catchers. The history of the long-haired Angoras is entirely unknown.

This brief sketch of the background of our more important domestic animals indicates that many of them came from Asia to Europe, there to be crossed with domestic forms. The discovery of the Minoan culture of Crete shows the importance of that island in this transfer.

> Old Crete, indeed, formed a stepping-stone over which most of the domestic animals of Asia and Africa passed to reach the mainland of Europe. The geographic position of Crete was exceedingly well suited to play this intermediary rôle, for in the first place this island lies equidistant from the three continents, and, besides, it possessed a considerable navy even at the time of Minos, whose ships were in close touch with the east and south. Even as far back as 3000 B.C., a decided cultural influence from Egypt affected this large island of the Aegean Sea, while the Asiatic influence was still scarcely recognizable.[4]

Llamas

One other four-footed domestic animal of great local value remains to be mentioned. This was the llama of South America which was kept in herds of thousands about Lake Titicaca by the Peruvians. There are two species somewhat different in size. Neither can carry a load much greater than 50 pounds, but both have excellent wool and their flesh is good for food. They belong to the camel group at one time so highly developed in North America but which perished long before the time of man.

For present purposes we may ignore the smaller animals such as the rabbits and the guinea pigs which have furnished some food but as a rule have been kept as pets. No reptile has served man as a domestic servant of any special value. Man has domesticated many birds of considerable importance. In our account we may ignore those kept as pets, because of the beauty of plumage or song, and also those of very limited distribution and value, such as the fishing cormorants of Japan.

Geese

The first of domestic birds seems to have been the Nile goose which was tamed by the Egyptians at least 2000 B.C. It is stated that the art of incubating the eggs in manure had been discovered. This goose reached Crete but died out there ere it was passed on to Europe and died out also in its old home so that it is not represented in our modern breeds. The Chinese had domestic geese at a rather early time but the wild type has not yet been determined. In comparatively historic times the Europeans domesticated a goose, generally supposed to have been the graylag as this variety is still captured by the Laplanders and submits easily to domestication. This is the parent of the European varieties. In America the Canada goose has been tamed at times and might become a valuable sort.

Ducks

The mallard duck, which is widely distributed throughout the Northern Hemisphere, is considered to be the parent of all the breeds of domestic duck save the muscovy of South America. It has varied greatly under domestication as is evidenced by the contrast between the Peking and the Indian runner, the latter of which came to us from the Malay Archipelago. The quick response made by many of the species of ducks to protection indicates that others might be domesticated without difficulty.

Chickens

The chicken is by far the most important of all domestic birds. The red jungle fowl of India is the parent of all the domestic breeds. This bird was introduced into China about 1400 B.C. according to an old Chinese record. It was kept in domestic form in India at some time between 1200 and 800 B.C. Thence it spread north and then west into Europe. The Romans found it in Gaul, hence its Latin name, *Gallus*. Curiously enough it is not mentioned in the Old Testament and it was unknown to the Ancient Egyptians and the Greeks of Homer's day. It is figured on Babylonian cylinders by 700 B.C. Later on it was spread through Africa by way of Egypt. It was brought to America by the Spaniards. More recently Asiatic types have been brought here while American varieties have been sent to Asia, so that it has encircled the world. Its importance may be estimated by the fact that there are over 300,000,000 chickens in the United States at any given time and the yearly value of birds and eggs is approximately 1 per cent of our total production of wealth.

Guinea Hens

Unlike the chicken the guinea hen has shown almost no variation under captivity. It has been half-domesticated since the time of the Phœnicians. It came from West Africa and is increasing in popularity as wild game diminishes, owing to the quality of its flesh. It quickly reverts to the wild state as in Haiti, where the hunter finds it a difficult matter to get within gunshot of it.

Turkeys

The only important contribution of America to the domestic fowls is the turkey which had been domesticated in Mexico and was taken to Europe by the Spaniards as early as 1530. There is written evidence of its presence in England by 1541.

From Europe it was brought to the United States. Possibly because of its southern origin, it is a difficult bird to rear. Although it may have crossed with the local wild turkey it has varied little under domestication and there are but few breeds. The largest of these, the bronze, is much smaller than the wild bird. The origin of its name is a mystery.

Pigeons

There remains to be mentioned one of the oldest of domesticated birds, the pigeon. It is descended, as Darwin proved, from the rock dove which still ranges wild from England to India. Our earliest record is a picture on the wall of an Egyptian tomb of some 2500 years B.C. Solomon is said to have used it to carry messages and the results of the Olympic games were sent to the cities of Greece in like fashion. Like the chicken it has varied greatly under domestication and it is not easy to realize that all the many forms of to-day have a common ancestor.

Ostriches

The ostrich at one time inhabited parts of Asia as well as Africa but was exterminated in the former before the Christian Era. No attempt was made in Africa to rear it until 1863. This proved so successful that within twenty years nearly a third of a million were in captivity. By 1913, South Africa possessed about 900,000 and the annual production of plumes was worth $13,500,000. Twenty-two ostriches were brought to California in 1882 and by 1910 there were 6,100 breeding birds, chiefly in Arizona and California. Fickle fashion changed during the war and the market for plumes disappeared so that by 1920 only 231 birds were reported on the farms. The incident is of value as showing what man may be able to do with other forms of life hitherto neglected if circumstances warrant the experiment.

The savage does not hesitate to eat insects but civilized man soon loses his appetite for such food. Out of the vast host of insects there are but two which man has tried in any sense to domesticate, the honeybee and the silkworm.

Bees

The keeping of bees antedates our records and has been found among peoples of many parts of the earth. Several species have been used by our own people, one of the commonest being the dark-colored European bee. The Spaniards introduced this into Mexico in early days. It reached Pensacola by 1753, New York by 1797 and was known west of the Mississippi at the latter date. The last century has witnessed a great change in the methods of culture. The old straw kep has yielded place to the modern hive. Most important is the use of some comb foundation. Apiaries of two to three thousand colonies are now reported. Over 100,000,000 pounds of honey are used yearly in the United States.

Silkworms

The mulberry silkworm, according to Chinese records, was kept as early as 2640 B.C., when the Empress Si-ling encouraged its culture and the planting of mulberry trees. The worm is not known in the wild state. It reached Japan, via Corea, in the third century of our era. Somewhat later it was taken to India, thence to Persia. Aristotle was the first Western writer to give an accurate account of it. At the beginning of the Christian Era raw silk was well known in Rome and was worth its weight in gold. It was used by women at first and under Tiberius and Vespasian its use by men was prohibited. The exportation of the worm from China was prohibited, but Justinian, seeking to obtain a monopoly, secured, through two Nestorian monks, some eggs which they brought in bamboo tubes from China to Constantinople in A.D. 555. Until 1865 all the silkworms in Europe were the descendants of these eggs. In Georgia and

South Carolina considerable raw silk was produced and sent to England during the years 1735-1766. For a time the industry prospered in Connecticut, the product being used locally, and valued at $200,000 yearly. In 1830 there was a boom over the introduction of the Chinese mulberry, as much as five dollars being paid for twigs 2 feet long, but the boom burst in 1839. The industry could be carried on here but the labor cost is prohibitive. According to the *Encyclopædia Brittanica* the world now produces some 42,000,000 pounds of raw silk yearly, the chief sources being China 13,000,000, Japan 11,000,000, and France 1,276,000 pounds respectively.

Brief and inadequate as is the foregoing account it contains, nevertheless, mention of all the types of animals man has thought it worth while to domesticate during the last ten thousand years. It does not include any consideration of the attempts to rear fish, nor such special uses of animals as that of rats for breeding experiments and investigations into disease. The animals named have been used by man for transportation, as sources of power for agriculture, and for clothing and food. Who can estimate, justly or accurately, the assistance they have given him on the hard and long road which led from the deep woods to modern civilization? Does not their presence or absence go far towards explaining some of the differences that we find between two groups of peoples in environments otherwise similar, Europe and North America, for instance? Some of these questions must be considered in our later discussions of human progress.

Cultivation of Plants

The history of cultivated plants is similar to that of the domestic animals. Out of the untold thousands of animal species man has domesticated but a handful. Of the 150,000 species of plants not more than 300 have been cultivated to any great extent. This statement does not apply to ornamental plants. Agriculture, moreover, is very ancient. As De Candolle well says: "Men have not discovered and cultivated within the last two thousand years a single species which can rival maize, rice, the sweet potato, the bread fruit, the date, cereals, millets, sorghum, the banana, soy. These date from three, four or five thousand years, perhaps even in some cases, six thousand years."[5] So ancient is this cultivation that in many instances we have been unable to determine the wild species from which the cultivated forms have come. This is true of wheat and maize. In some instances it is true even of ornamentals such as the beautiful tree, the ginkgo, long planted by the Chinese and now popular in Europe and America. It is well known that plants vary rapidly under cultivation. When man began to notice that certain plants were more productive of seed, or grew better under given conditions, we shall never learn. The quotation from Virgil at the first of the chapter indicates that these facts were well known to him, even if later forgotten in Europe. In as much as man did begin to select his seed it is likely that the cultivated varieties are better than the wild types from which they have come. We are thus prepared to learn that most of the cultivated plants have developed in a few of the older centers of civilization from which they have spread to other parts of the earth. Four regions have contributed the bulk of our plants: (1) Southeast Asia, (2) Western Asia and Northeast Africa, (3) Europe, (4) Central and South America.

Plant Sources

From the first came the orange, lemon, peach, apricot, banana, sugar cane, coconut, rice, tea and cotton. From the second came the olive, sour cherry, plum, almond, quince, fig, date palm, onions, cabbages, radish, turnips, lettuce, spinach, lentils, garden peas, numerous gourds and melons, coffee (from Abyssinia), and wheat. Europe contributed the apple, pear, gooseberry, strawberry, currants, oats, while rye is a late comer from the district north of the Caspian. Central and South America furnished the potato, sweet potato, pineapple, cacao, tobacco, tomato, guavas, manioc and maize.

It will be noted at once that most of Africa, South and North America have made but meager contributions to the list of the world's important plants. De Candolle says:

> A noteworthy fact is the absence in some countries of indigenous cultivated plants. For instance, we have none from the Arctic or Antarctic regions, where, it is true, the flowers consist of but few species. The United States, in spite of their vast territory, which will soon support hundreds of millions of inhabitants, only yields as nutritious plants worth cultivating the Jerusalem artichoke and the gourds (pumpkin and squash). Zizania acquatica (wild rice) which the natives gathered is a grass too inferior to rice to make it worth planting. They had a few bulbs and edible berries, but they have not tried to cultivate them, having early received the maize which was worth far more.[6]

In the main this statement is true, but at least six varieties of American plums have proved valuable and the merits of cranberries, blueberries and Kentucky blue grass are well known. It is also true of Africa, and yet one African contribution, the watermelon, is our most valuable vine crop and was known in China by the tenth century. Guinea grass has proved an acceptable forage plant in the West Indies where the better grasses do not grow. In recent years the Pará rubber tree of Brazil has become very useful. We may realize the situation better, perhaps, if we recall that our chief food plants are wheat, corn and potatoes; our chief forage crops are the timothy and clover of Europe and the alfalfa of Asia; our chief fruits the apples and citrous fruits. Not one of these is a native of the United States. What has happened here has happened in most places. It is easier to carry along the main crops on which man has depended, or to take over the crops of other folks, than to go through the long process of cultivating a new wild form. Nevertheless we are searching the earth for promising forms and at times we may be successful. Meantime any change in the methods of life may make possible the use of some form hitherto neglected as in the case of the rubber tree. In as much as the list of plants is too long for any detailed sketch of their history we must content ourselves with a few words about some of the most important.

Wheat is one of the oldest of the cultivated plants and is to-day the most important food plant of the temperate zones. It was grown in China by about 2700 B.C. It appears to have started in Syria where there still survive closely related wild forms. Corn (maize) is a native of Mexico and is closely related to teosinte which still grows wild and with which it produces fertile crosses. The Indians had domesticated this plant and its culture had spread north as far as New York prior to the coming of the whites. The potato is a native of the high valleys of Peru whence it was taken to Europe as early as 1565. At first it was used in Europe chiefly as food for the stock but it soon became important as human food in Ireland where it was substituted for the cereals by the first of the nineteenth century. It got a foothold in Germany after 1772 and to-day the German production is many times that of the United States. Here it ranks sixth in value among our agricultural crops.

Tropical Fruits

The most valuable fruits of the tropics are the mango and the banana; the chief root crop is the manioc, and the best cereal, rice. The mango is to tropical dwellers what the apple is to those of temperate climes. It is a native of southern Asia cultivated for some four thousand years. It spread into Africa and was early brought by the Portuguese to Brazil and became common throughout the West Indies in the eighteenth century. The ordinary banana as well as its very close relative the plantain, which must be cooked to be palatable, comes from south Asia also. The banana family gives us some beautiful ornamentals as well as one of the best fibers, the Manila hemp, so widely grown in the Philippines. Rice comes to us from Asia bearing an Arabic name. It replaces wheat in the tropics though of somewhat lesser food value. Manioc, better known to us under the name cassava, is a variety of the many manihots of Brazil, cultivated so long by the Indians that the wild original is uncertain. Manioc was taken by the early explorers back to Africa to become a valued food plant there.

Tomato

The one important addition to the food supply of the world which has resulted from the variation under domestication is the tomato. This plant, a native of South America, was grown for about three hundred years in the garden as an ornamental because of the bright color of the fruit. The fruit, however, was hard and full of seeds and was not favored for food. The south Europeans began to eat it and the custom spread. It was little grown in America before 1835 and its great development did not begin until 1870. The tomato has become not only one of the best liked of vegetables but it is the most important of canned foods at the present time.

Fiber Plants

Flax, the source of our linen cloth, has been under cultivation so long that we are uncertain of its origin. It came probably from a variety found wild from England to western Asia. The most important source of fiber is the cotton plant. The origin of the long and silky sea-island cotton is disputed but the weight of authority seems to favor tropical America.

The short-staple cotton came from India and was often cultivated as an ornamental plant in Colonial gardens. Owing to the difficulty of separating the fiber from the seed it was not important until the beginning of the nineteenth century. Long before the Civil War it had become the most valuable crop of the South where to-day some two-thirds of the world's supply is produced. Fear of the destruction of the crop by the boll weevil and the desire to break our monopoly have led to experiments elsewhere and large acreages are now planted in Asia and Africa. Our average production is about 13,000,000 bales. From the seeds we are now extracting some 200,000,000 gallons of oil yearly and are turning much of this into 350,000,000 pounds of oleomargarine which is equal to over one-third of the butter production. The cotton seed alone is of greater value than the commercial apple crop.

Sugar

One of the most striking changes in man's diet in recent centuries is the increased use of sugar. Honey and the juices of certain fruits were the only forms of sweetening known to the classical people of the Mediterranean. As late as 1482 sugar is said to have been worth $2.87 a pound in Europe. Early in the nineteenth century Europe did not use over 3 or 4 pounds per capita in a year and not over 8 pounds in 1850. In 1865 the United States used about 18 pounds per capita as against 118 pounds in 1926. This is about four times the world consumption and three times the European consumption. The commercial sugar production of the world in 1925-1926 was about 27,707,000 tons of which 67 per cent was cane sugar and 33 per cent beet sugar.

Sugar cane has been grown in southern Asia from time immemorial. In so far as we know no sugar was made until the Christian Era and it did not enter into commerce before A.D. 300. The culture of the cane spread even as far as

Hawaii to the East and was brought into Africa and Europe by the Arabs. During the fourteenth and fifteenth centuries the Venetians had a monopoly of supplying refined sugar to Europe. In 1420 the Portuguese transplanted the cane to Madeira. Columbus brought it to Santo Domingo on his second voyage. It spread to the other islands and to Brazil but did not get a good foothold in Louisiana until 1794. Negro slavery in the Western World was one of the unexpected results of the transplanting of sugar. Until recently the sugar cane has remained substantially unchanged through the ages as it is propagated by cuttings. Within the last forty years improved varieties have entered into commerce.

The presence of sugar in the beet was discovered by a German chemist, Marggraf, in 1747. It did not become a commercial success for many years. By selection beets containing 15 to 18 per cent sugar have been developed. The sugar beet grows in the temperate zone and Germany produces about one-fifth of the total, while Cuba produces about one-fifth of the cane sugar of the world.

The development of the sugar industry has depended in large measure on the growth of chemistry, for its manufacture is complicated. Disregarding the alleged evil effects of an excessive sugar diet it is evident that it has made possible the wider use of some of the bitter fruits and of some of the cereals which are about as appetizing as sawdust unless cream and sugar be added. It is sugar which has made possible the present vogue of soft drinks. It is doubtful if any substance has a greater influence on human diet than sugar.

Rubber

It is to the plant world that man has turned for much of the material used in his industry. At first local resources are utilized for firewood and building material. To-day lumber may be shipped around the world if need be. Changing conditions of industry due in part to new inventions are compelling man to make new demands on the vegetable world. One illustration must suffice. Early travelers found the Indians of South America playing with rubber balls. Slowly there grew a demand for the substance, particularly after Goodyear labored for years, using all his means and all his credit even to the extent of going to jail for debt, until he made the substance tractable. There are many plants which produce rubber but the best is the Pará rubber tree of Brazil. From that country 2,671 tons of raw rubber were exported in 1860 and 38,200 in 1910. Up to 1900 wild plants were the source of supply but by this time the world began to realize that the demand would grow and the English and the Dutch began to create vast plantations in Ceylon, India, Sumatra and elsewhere. Then came the invention of the automobile and the demand jumped until to-day 800,000,000 pounds of rubber are used yearly in tires, or about 70 per cent of the total consumption of rubber. By 1913 there were 25,000 acres planted to rubber in Ceylon; 420,000 in the Malay States, 40,000 in India, 45,000 in the German colonies, and 100,000 more in Mexico, Brazil, West Indies and South Africa. The war temporarily stopped the increase but it has started again and plans are under way for large plantations under American control in Liberia and Brazil. In addition to automobiles the growth of the electric industry has strengthened the demand for rubber. The Pará rubber tree is doubtless the most important addition to cultivated plants made during the last century. In recent years a Mexican plant, guayule, has received attention and 8,500,000 pounds of rubber were made therefrom in 1926. It is a plant of semiarid areas and is being cultivated in California and the Southwest.

Drugs

Man has long drawn on plants for his medicines. Probably the cultivation of the cinchona tree of western South

America from which quinine is made is the most important recent development. These trees were taken to India in 1861 and have been successful. It is another illustration of the fact that man cannot longer depend on wild plants but must select and grow the types needed by him, for the world must draw its supplies from the areas in which given plants prosper.

Man has long cultivated many of the plants from which he has made his stimulants. To the tea and opium of Asia must be added the coffee and cola of Africa, the coca of South America and the tobacco of tropical America. No good habit has spread over the world faster than the use of tobacco. Our southern states produce to-day about one-third of the world's supply.

Ornamentals

As these lines are being written a glance out of the window reminds one that "man does not live by bread alone." The grackles are building their nests in the Norway spruces. The Hugonis rose of Asia is putting on a coat of green; bleeding hearts and peonies are pushing through the ground; the crocus is in bloom. From time immemorial man has sung of the beauty of the flowers and long ago began their cultivation. As civilization developed and commerce grew the world has been ransacked to find flowers, shrubs and trees to be used as ornamentals. Gradually man changed from the collecting of wild plants to the growing of selected types and the nurseryman appeared, drawing his supplies from all over the earth. As population increased it became necessary to grow flowers in quantity. From the greenhouses almost in sight of the writer thousands of sweet peas, roses and carnations are being cut for the market. A little later there will be fields of peonies whose cultivation was first undertaken in China, and of gladioli which came to us from South Africa. Many of our shade trees, even, have been drawn from other lands as the eucalyptus of the Pacific coast witnesses. In return we have supplied laurel and rhododendron to Europe and have sent the agaves and opuntias to the warmer lands. The last have escaped from cultivation in the semiarid countries and have become a veritable menace to the farmers of parts of Australia. We have been so anxious to collect strange forms from other countries that we have often neglected the best of our own species. The dogwood is one of the finest flowering trees of the world but there are few to be found in the yards of our eastern farmers.

Ornamentals offer an interesting sidelight on history. Commerce demands that necessities such as foodstuffs shall be standardized and new things must be tested and introduced gradually. The desire to get something "different" stimulates variety in ornamentals. In a catalogue on my desk of a leading supply house all the seeds for farm and garden are described on fifty pages but flower seeds and plants cover one hundred pages.

SIGNIFICANCE OF DOMESTICATION

Earlier man first cultivated annuals or biennials rather than the more slowly growing perennials. The last he used in countless ways but depended on the wild supply. Only recently has man begun to cultivate trees to any great extent, but this has become an immediate necessity and the industry is spreading rapidly.

The story of the domestication of plants and animals is but one aspect of the upset of the balance of nature which has been discussed. Does the average person realize that man is creating a new world? Does he visualize the fact that the larger mammals are disappearing from earth, save those which man keeps as domesticated helpers, to such an extent that scientists are already speaking of the end of the era of mammals? Does he realize that even the trees of earth are doomed save those which man preserves? No longer can man depend on wild plants and animals to supply his needs. He is replacing them with newer sorts. Can these newer types survive without man's protection? It is evident that the chief problem of man in the future is to lie in the effort to control the smaller forms of life, for it should not be forgotten that if we compare the smallest with the largest forms of animals the average will be about as big as a good-sized fly.

Possible Utilization of Bacteria

Until very recently man's use of the lower forms was largely accidental and unconscious. Long ago, to be sure, man learned the difference between leavened and unleavened bread but the cause of the difference was not understood. Long ago he learned to transfer some of the "mother" from an old lot of vinegar to a new barrel but it was not until Pasteur and his contemporaries of the middle of the last century discovered the nature of fermentation as well as of contagious diseases that the era of the conscious use of yeasts and bacteria became possible. In most cases, even to-day, man but provides favorable conditions for the growth of bacteria and trusts that the helpful forms will do the work desired. This is the case in the purification of sewage in tanks and the fermentation of ensilage in silos, and in the ripening of hay in mow or stack. It is the case also in the retting of flax, the tanning of leather, the making of pickles and in homemade cream and butter. In the creameries and cheese factories as well as in the wineries greater care is now given to the exclusion of harmful types. Yeast has become a standardized product. In the fight against disease we find the most discriminating use of bacteria to-day with the greatest care in the production of pure strains. There seems to be a definite field for their use in industry in the near future, as in chemistry, for some of the bacteria can distinguish between different sugars far more accurately than any man. All this is but an indication that man will learn to utilize (domesticate does not seem to be the proper word) many of the microscopic forms of life whose very existence was unknown to him a few years ago. A century hence a family will probably send over to the neighbors for a batch of microbes as nonchalantly as it now asks for the loan of a loaf of bread.

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CHAPTER VII

MAN AND HIS MACHINES

Man's earliest arms were fingers, teeth and nails,
And stones and fragments from the branching woods;
Then copper next: and last, as latest traced,
The tyrant, iron.

—LUCRETIUS

THE DEVELOPMENT OF CULTURE

Historically speaking the most important discoveries and inventions of man are not those of recent years, the electric light and radio, for example, but those which for long ages and over wide expanse of earth have been used by man in his daily life. Who invented the bow and arrow, perhaps the most useful tools in the securing of game and the best of weapons, until the invention of the gun? What genius discovered the art of fire-making and made possible the use of cooked food? Was it a woman or a man who first used needle and thread? We cannot hope to answer such questions. The best we can do is to keep digging away until the story of the development of man's culture is better known than it is to-day.

It so happens that the history of Europe is better known than that of any other part of the world. This is true even if we are not certain of the race to which the leaders of the classical culture of ancient Greece belonged. Here we have the best evidence of the culture of primitive man. Our classification, therefore, must be based on Europe in spite of our knowledge that the culture centers of Asia are much older. Save for the region east of the Mediterranean, Asia is almost unexplored and in few parts of the continent are there people who are likely to appreciate the meaning of any evidence of early times that may come to light. The same is true of Africa.

Early Discoveries

We have to assume that primitive man used a branch for a club or picked up a stone for a hammer. In time he began to chip off pieces until the core was better fitted to the shape of his hand. He entered then the paleolithic or old stone age which lasted in Europe until about 10,000 years B. C. Then we come to the neolithic age in which the older arts continue, just as man to-day uses a stone to drive a stake, but in which we find some new traits. Among these are the use of bow and arrow, pottery, the hewn ax, a wide employment of bone and horn, while the dog appears as a domestic animal. It is interesting that the first evidence of bow and arrow is a crude cliff drawing in eastern Spain. As the neolithic age matures between 5000 and 6000 B.C., we find tools of stone, ground rather than chipped, the ax, chisel, hammer and maul, but it is not until the end of the era that well-ground and perforated axes are found in Europe. It is more than possible that these were copied from metal axes already in use in Asia. Bronze was used in Spain and Italy by 2500 B.C. and in north Europe about 1900 B.C. Iron appears in Italy about 1100 B.C., in central Europe about 900 B. C., and in north Europe about 500 B.C.

Early Metals

Long prior to these dates we know that advanced civilization existed in Asia and Egypt. Copper was used in Asia at least four or five thousand years before Christ. Seemingly it was the first metal used by man, though gold and silver are very ancient. It is, however, soft and not valuable where cutting edges are desired. Bronze, an alloy of copper and tin, was in use in Asia and Egypt before 3000 B.C. Where the tin was obtained we do not know. Brass, an alloy of copper and zinc, is much later. Bronze is much harder than either of the component metals and takes a better edge. Iron appears at least two thousand years later than bronze and as an inlay on bronze. There is an added difficulty about iron as it rusts so rapidly that only under the most favorable conditions would any small iron object survive several thousand years. Iron is mentioned only four times in the first four books of the Bible as against eighty-three times for bronze. Our earliest record of the use of iron in Egypt is during the time of Rameses the Great. The later metal culture of the European continent is clearly derived from this older region.

Later Metals

The first metals used by man then were those which occur in relatively pure form in the rocks from which they were taken by a simple process of heating, doubtless discovered by chance, or were found in small masses in the drift as, for instance, gold. They were soft metals with low melting points. Gold may have been the first metal recognized by man. It has always been highly prized. A natural alloy of gold and silver is rather common and was often used for coins by the ancients under the name of elektron. Silver seems to be later and was often more valuable than gold. There is evidence that the method of separating gold from silver was known by 550 B.C. for at that date a gold coinage replaces the elektron in Lydia. As already stated, tin was first used as an alloy of copper. It was not distinguished clearly from lead and was called white lead. Indeed the differences between tin, lead and antimony were not known until A.D. 1450. The iron first used was probably meteoric in origin just as the Greenlanders to-day search for bits to put on their cutting instruments. Mercury was known by

400 B.C. The ancients mixed a zinc ore, calamine, with a copper ore and by heating secured the desired alloy. Early in the Middle Ages pure zinc was known in India and China and pieces were brought to Europe. It was not produced in Europe before A.D. 1700. Bismuth was discovered in the fourteenth century. Platinum was used by the Indians of Central America in small amounts but was not used by the Europeans until the nineteenth century. German silver, an alloy of copper, zinc and nickel, was discovered in China. Prior to the last century only seven metals and a few alloys made from them were of any general service to man. Among these iron has grown steadily in importance and it may be called the metal base of our present civilization. A series of discoveries has given us a number of metals hitherto unknown which are or will be of great value in some instances but most of which are too rare to be of much service to man. One of these, aluminum, is likely to be the metal of the future. Others, like cadmium, chromium, iridium and tungsten, are important in new alloys, most of them having very high melting points. White cast iron melts at 1075° C., chromium at 1587° C., iridium at 2200° C., and tungsten at 3000° C.

Limited Supply of Metals

Metals offer a great contrast to the plants and animals described in the last chapter. They exist only in certain places and fixed quantities and the available amounts are rather limited. Once mined and used much of the metal is so scattered that it can never be recovered. Man faces, therefore, the necessity of finding new sources, of which there is somewhere an end, and the necessity of using the poorer ores for he will use the best first. From the beginning of the Christian Era to the discovery of South America no new source of gold and silver was found. What this meant to the steadily increasing population of Europe the history of the coinage of the various countries and the search for gold reveals. By contrast these metals were being produced in such amounts at the end of the nineteenth century that money values were being disturbed. On the other hand most of the tin of the world comes from the Dutch East Indies, the older sources are gone, no new supply is in sight and we appear to be facing a world without tin within a comparatively short time. Since man cannot grow new supplies he faces the necessity of substituting some available metal for any which may disappear unless he masters the art of transmutation.

Culture and Invention

Human achievement is always relative. The invention of the bow and arrow was probably as difficult as that of the steam engine. We happen to know the steps taken by the inventors of the latter but the process followed in the first is a matter of speculation. Man can fuse copper and even iron on an open hearth but the production of heat enough to melt tungsten requires a great development in the construction of furnaces and the use of power. Aluminum remains a costly curiosity of little practical value until the electric furnace is devised. Modern surgery turns on new lights and instruments as well as better trained surgeons. In human history, therefore, ere the older metals can be put to many of their present uses, new methods of production must be learned, new processes of manufacture devised. Iron tools such as plows do not replace the older agricultural implements much before the last century and their use was often condemned as impious and it was claimed that they would poison the ground and destroy the crops. Iron, coal and the steam engine are the trinity underlying our civilization.

THE METALS

Iron Supply

Arrhenius estimates that the production of iron in the world in the year 1500 was about 50,000 tons; in 1800, 800,000; in 1900, 41,250,000 reaching a high point of 77,000,000 tons in 1913, dropping then on account of the war. Taking all known supplies and estimating that the rest of the world is as well provided he thinks that 425,000,000,000 tons of iron are available. With the steady increase in consumption assumed not many centuries will pass ere man is conscious of a decrease in the supply. Already he is turning to lower grade ores for not more than 1,300,000 tons of ore having 60 per cent of iron are in sight and of this amount Sweden possesses two-thirds. Arrhenius observes: "But about the metal situation we can only say that man will soon pass from the Age of Heavy Metals to the Age of Light Metals. The light metals, and above all aluminum in the form of its alloys will then replace iron and steel."[1]

Pure iron is almost nonexistent. Slosson thus explains its rarity:

> Iron is one of the most timid of metals. It has a great disinclination to be alone. It is also one of the most altruistic of the elements. It likes almost every other element better than itself. It has an especial affection for oxygen, and since this is in both air and water, and these are everywhere, iron is not long without a mate. The result of this union goes by various names in the mineralogical and chemical worlds, but in common language, which is quite good enough for our purpose, it is called iron rust.
>
> Not many of us have ever seen iron, the pure metal, soft, ductile and white like silver. As soon as it is exposed to the air it veils itself with a thin film of rust and becomes black and then red. For that reason there is practically no iron in the world except what man has made. It is rarer than gold, than diamonds; we find in the earth no nuggets or crystals of it the size of a fist as we find of these.[2]

Iron Alloys

When we speak of iron we have some alloy or compound in mind. Iron containing less than 0.4 per cent of carbon is soft and easily malleable; but, if the carbon content reaches 2 per cent, it is not malleable and is called cast iron or pig iron. "A very slight content of phosphorus in iron makes the latter brittle at room temperature. A little sulphur makes iron brittle at red heat, so that in hammering or forging it may break. This latter undesirable feature may be decreased by adding manganese."[3] The use to which iron is adapted turns on the content of these foreign substances. Alloys of iron and silicon are valuable in many articles such as gun barrels. Silicon, aluminum and iron make an alloy very useful in electrical machinery. The addition of manganese destroys the magnetic properties of steel, about 12 per cent of manganese giving the best results.

> Alloys of iron with nickel have also remarkable and useful properties. The first of such alloys were prepared by Stodart and Faraday in 1882. . . . So by choosing the right combination it is possible to make from such alloys wires or bands which do not change their length with changing temperature. These have found use for the manufacture of measuring tapes used in geological measurements. Bars of such metal are used for the pendulums of clocks. . . .[4]
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> The metal which does not expand on warming is called "Invar" (unvarying). It contains about 36% nickel, 0.5% carbon and 0.5% manganese. At temperatures under 200° C. it changes very slowly, and it is therefore aged before use by warming it gently for some time. It can be forged, rolled, polished, and drawn into thread or wire, and can take a beautiful polish. Steam harms it very little; it is not likely to rust. . . .[5]
>
> Nickel steel of 0.8% carbon content and with less than 5% of nickel is remarkable for its high co-efficient of elasticity and for its tensile strength. It is used for armor plate, cannon, large axles, auto parts, and in steel-framed buildings.

The addition of chromium increases the hardness of steel:

Chrome steel is used for the manufacture of projectiles, which must have great penetrability, and also is used for cutting tools and for articles which are to receive heavy friction. Also it is used for the protective screens for guns, for steel helmets, as well as for the equipment and armor of battleships. . . .[6]

Tungsten steel is used in machines that drill and bore, where at a rapid work-pace the cutting parts are liable to become greatly heated. . . . In such steel there is commonly present, also from 3 to 4% of chromium and about 1% of vanadium. . . . Steel containing over 3% molybdenum has properties similar to tungsten steel but is less brittle, though ordinarily more expensive.[7]

Steel

Steel is simply iron containing a small amount of carbon which has been hardened by some rapid process of cooling. Not until Bessemer invented his process in 1856 could steel be produced cheaply. The cost of steel rails for the railways soon fell from about $175 per ton to the neighborhood of $30 per ton.

The making of steel is the epic of modern civilization though we have been more conscious of its practical benefit and have heard more of its problems, for the poet has not yet appeared.

Iron Production

The Middle Ages were well advanced ere iron was generally used for anything but weapons and a few tools. A little furnace with bellows such as the blacksmith uses to-day were employed for the reduction of ores. Not until 1728 was a mill for the rolling of sheet iron introduced, while grooved rolls for the making of bars and rods were devised about 1783. During the eighteenth and nineteenth centuries many improvements were made in the manufacture of steel and iron, the demand having been caused by the extended use of the metal in machinery and above all, perhaps, by the railroads. "About 1740 the production of pig iron in Europe was not more than two pounds per capita. In the United

States the per capita use in 1810 was only about 14 pounds; in 1850, just before the modern improvements began, it had risen to about 49 pounds, while in 1920 it was nearly 700 pounds. . . . More iron is consumed in a decade now than in the previous 100 years."[8]

Iron and steel have been used wherever strength has been needed or wherever first cost was important. It is difficult to see how the prairie lands of the Middle West could have been fenced had it not been for the barbed wire. But iron exposed to the weather or to the action of many liquids rusts quickly. By covering any tool with a coating of nickel its appearance has been improved as well as its lasting qualities. Iron coated with tin has made possible the canning industry and the tin roofs of our buildings. Iron coated with enamel is used in bathrooms and kitchens. For many purposes, however, iron must give way to the next common metal, copper, and some of its alloys.

Copper

"The most important use of copper to-day is in electrical conductors. It is valuable for this purpose because of its high electrical conductivity. If this is set at 100 for pure copper, the addition of but 0.05 per cent of carbon lowers it to 80.5; a content of 0.87 per cent of phosphorus drops it to 20.6, while 2.8 per cent of arsenic carries it down to 14.12."[9] To-day the elimination of these impurities is done by electrolytic refining, another illustration of the dependence on correlated development, for older methods would not have given us the desired results. Bronze remains valuable, for copper is not easily cast. For small coins, bells and art castings bronze is used. Brass is esteemed for castings and bearings in our machines and in the sheathing of steamboats. Copper combined with silicon and manganese is of special value wherever the corrosive effects of acids must be minimized and the alloys go under various names such as "everdur." Copper is also combined with aluminum and used for household and art objects.

Zinc

Zinc became very useful after the development of sheet iron and the electric industries. Zinc oxide is used as a paint. Zinc coated on iron makes an excellent roofing material. Zinc nails are often used in shingling operations.

Aluminum

Curiously enough the commonest metal on earth, aluminum, was discovered just one hundred years ago, 1827, and no practical means for extracting it from its ore, bauxite, was devised until 1889. Prior to that time it cost about twenty-five dollars a pound to produce but it can now be secured for a few cents a pound through electrolytic processes. Already it has rendered obsolete the heavy iron pots of the kitchen. It is used in airplanes as well as automobiles and, with its alloys, is destined to become one of the most widely used metals. The production in the United States jumped from a few tons in 1890 to 90,000 metric tons in 1923, while Canada in the last year produced 12,000 tons and Europe 68,000. By itself aluminum is not strong but the addition of 5 or 10 per cent of magnesium produces an alloy almost as strong as steel. The alloy of aluminum and calcium is lighter than aluminum itself and more resistant to acids. Calcium itself is a newcomer to the list of metals for it was almost unknown before the era of electric furnaces.

Tin

It is interesting to note that the chief uses of tin have been much changed in recent years and that the production of the first alloy, bronze, is relatively unimportant, whereas tin plate stands at the head. Much concern is felt as to the future supplies of tin. While the world's supply has not decreased, 103,500 long tons in 1910 and 139,482 in 1924, there is not much increase in production. Most of it is mined now in southeastern Asia and neighboring islands, with Bolivia as the only other important source. Once used most of the tin is forever lost, although considerable advance has been made in the recovery of tin and tin alloys. The figures vary much from year to year, the total value of tin and alloys recovered being given as $12,443,500 for 1922 and $25,316,000 for 1923. The average price for pig tin in New York for thirty years has been $36.61 per ton, ranging from a low in 1896 of $13.24 to a high in 1918 of $86.80 falling to $50.20 in 1924. As no new sources of supply are in sight the mining world expects a reduction in the future of our supply.

Lead

The world's production of lead in 1923 was 1,297,247 short tons, or about the same as for the preceding ten years, of which the United States produced 530,000 tons. The Bureau of Metal Statistics states that the uses made of lead for the year 1923 were: Storage batteries 20 per cent, cable coverings 17 per cent, white lead 17 per cent, buildings 10 per cent, red lead and litharge 6.3 per cent, ammunition 5.4 per cent.[10]

It is evident from this table that a large part of the lead used can never be recovered, as for instance, that used in paint and ammunition. Alloys are again important. Solder is generally made of an alloy of tin and lead because of the low melting point, and to this bismuth is added. Rose metal, an alloy of bismuth, tin and lead, melts at 201° F. Storage batteries depend almost wholly on lead.

Noble Metals

Within the last generation man has come to appreciate the properties of another group of metals often called, and justly so, "noble metals." Platinum comes chiefly from the

Ural Mountains and was little esteemed when first discovered, even being used for small coins by the Russian government. It was soon found that this metal was rarely attacked by acids, hence, it came to be of great value in the chemical laboratory, and worth much more than its weight in gold. Now an alloy of gold and palladium costing about half the price of platinum is used by the chemists. The "diamond" points of our gold pens are often an alloy of osmium and iridium. These metals are all extremely rare, hence they find employment only in jewelry or other fields where first cost is not a prime consideration. Man would gladly use them widely if he could find them in greater quantity.

In connection with iron and steel, mention has already been made of yet another group which has been of great value to man but which likewise is rare.

> If tungsten ores were more abundant and the metal more easily manipulated it would replace steel for many purposes. It is harder than steel or even quartz. It never rusts and is insoluble in acids. Its expansion by heat is one-third that of iron. It is more than twice as heavy as iron and its melting-point is twice as high. Its electrical resistance is half that of iron and its tensile strength is a third greater than the strongest steel. It can be worked into wire .0002 of an inch in diameter almost too thin to be seen, but as strong as copper wire ten times the size.[11]

An alloy known as "stellite," composed of chromium, cobalt and tungsten, makes a better high-speed tool than can be produced from steel. The first metal filaments in the incandescent electric light bulbs were made of tantalum but this has been replaced by tungsten. One pound of molybdenum is said to give greater resiliency to steel than three pounds of tungsten and increasing use is found for it. Zirconium might be found to be the noblest metal of them all if it could be got in quantity.

It should not be forgotten that over one-half of the metals have been discovered in the last century and therefore it is not a matter of surprise that no use has been made of many of them. Most of them are extremely rare in so far as we now know and until some special use is found for them the cost of production will remain prohibitive. The story of radium is a fascinating illustration of what can be done when the effort is deemed worth while. As Slosson says:

> The so-called "rare elements" are really abundant enough considering the earth's crust as a whole, though they are so thinly scattered that they are usually overlooked and hard to extract. But whenever one of them is found valuable it is soon found available. A systematic research generally reveals it somewhere in sufficient quantity to be worked. Who, then, will be the first to discover a use for indium, germanium, terbium, thulium, lanthanum, neodymium, scandium, samarium and others as unknown to us as tungsten was to our fathers.[12]

Other Elements of the Machine Age

Fire-Making

One of the most ancient and valuable arts of man is that of fire-making. The most primitive folks known to us possessed this art. I timed an Indian once and saw him start a flame with a little wooden hand drill in a trifle over twenty seconds. The boy scout who can do this is proud of his skill, yet every Indian boy knew how. It was a big advance when some genius devised the bow drill and was able to increase the speed of the drill. Ages passed ere man learned to use a flint and steel for striking sparks into some tinder and this remained the common method among our ancestors down to the first of the last century. In the old villages of New England it was considered easier to go to a neighbor's for a shovel of wood coals than to make a new fire. The word match was originally the name applied to the fiber which carried the flame to the oil of the lamp or the powder of the gun.

Matches

In 1680 phosphorus was rubbed against light splints of wood which had been dipped in sulphur, thus producing a flame, but the process was rather dangerous. In 1805 Chancel at Paris devised a scheme of keeping asbestos soaked in sulphuric acid in a bottle. Into this was stuck a sulphur-coated stick tipped with chlorate of potash and sugar, the fire resulting from chemical action when the stick was withdrawn. The writer well remembers being told by an old man who had been a student at Yale what a wonderful invention this had seemed in his college days. Walker of England invented a friction match in 1827 and in 1833 the common phosphorus friction match appeared in several places, notably Vienna. The first friction match was made in the United States in 1836, the first safety matches were made in Sweden in 1852.

Light

When man had learned how to make fire he did not have to wait for the full moon to turn night into day. He built his bonfires and used the pine knots or their equivalent to cast light on his path. In time he devised a shallow dish filled with animal or vegetable oil with a little wick of some fiber. Candles of wax or beef tallow were made by the Romans and there were guilds of candle-makers in north Europe in the thirteenth century. Sperm candles appeared about 1750 and became the standard of light. Even to-day we speak of candle power, though it is but a phrase to most of us, by which we mean a sperm candle 1/6 of a pound in weight burning 120 grains per hour. A private house in England burned coal gas in 1792; coal gas was used in London in 1807, though it was not common until 1819. The use of kerosene was not general even in America until after 1859. Electric light was still a curiosity at the Centennial

Exposition of 1876, and the use of acetylene light is still later. Just when electricity threatened to destroy the coal-gas industry the almost accidental discovery by Carl Auer of the properties of the newly found metallic element cerium and thorium made him Baron Auer von Welsbach, gave us the mantles bearing the name and the automatic lighters, and saved the gas industry. No better or more fitting compliment has ever been given any man than the dubbing of our days as "The Era of Edison," for it is to him that most credit is due for the electric light.

Fuel

The production of light for heat requires fuel and for this man turned again to nature, and the commonest fuel throughout the ages has been wood. It is hard for those of us who live in coal-burning regions to realize that the mass of humanity does not depend on it. It is even harder to realize that chimneys were unknown before the twelfth century and that fireplaces when first used had very short flues, the smoke making its way to the outer air through openings in the wall just above the fireplace. Coal was more or less known to the Romans and Marco Polo told of the burning of black stones by the Chinese. Small quantities of coal were mined in England prior to the coming of the Saxons. Not until the gradual deforestation which was noticeable by the ninth century was much attention paid to coal. There exists record of a charter of 1239 permitting the freemen of Newcastle to mine coal. Thereafter coal came gradually into use but at the end of the sixteenth century two ships were able to keep the London market supplied. There was much opposition to its use because of the smoke and dirt and people were forbidden to burn it during sessions of Parliament. In America bituminous coal was mined in Virginia about 1750 and at Pittsburgh in the following decade. Anthracite was discovered at Wilkes-Barre in 1762 but it came into use very slowly as the art of burning it was not understood. During the Revolutionary War it was used at Carlisle for the manufacture of firearms. As late as 1820 it took but 365 tons from Lehigh to satisfy the Philadelphia market. The importance of coal in our American life of to-day is well shown by the fact that it forms 37 per cent of the total tonnage of our railroads and that the cost of transporting it is greatly enhanced by the fact that the coal cars have to be returned empty to the mine.

Coal Mining

Coal mining is an excellent illustration of the correlation in industry and development which has been mentioned. Originally hand labor with picks was required for getting coal and the amount mined per man was very small. Then came the use of gunpowder to blast off large pieces. Dynamite was available about 1866. The coal once mined had to be carried to the surface in baskets. Then the mule was introduced to haul a couple of tons at a time. Finally science made possible an electric car replacing both man and beasts. But mines accumulated water, and the first working steam engine was devised to pump water from mines. The galleries accumulated dangerous gas and Davy invented the safety lamp in 1815. As the lower layers were reached ventilation became necessary and huge fans were devised. Compressed air was employed for drilling holes for blasts in 1861 and electric drills are often used to-day. Less than one-fourth of our coal comes from mines not using power machinery. As Harris and Butt well say, we

> very seldom reflect what it would mean were the practices of a hundred and fifty years ago applied in the mining and extracting of these metals. The price of coal would need to be multiplied at least two or three times; iron and steel products would be many times more expensive, petroleum products would probably never have been discovered by deep well drilling be-

cause power machinery is essential to this work; and aluminum, tungsten, and a great number of other minerals which we find almost indispensable would cost so much that they could not be used as they are to-day.[13]

In as much as the supply of coal is limited it is a matter of great importance that man utilize what he mines to the best advantage and waste as little as possible. It must be confessed that our present methods leave much room for improvement. It is claimed by the Division of Geological Survey at Washington that of every 2,000 pounds of coal dug:

600 pounds are lost in the process of mining.
31 pounds are consumed by machines used.
95 pounds are consumed in transportation or lost.
446 pounds go up in smoke.
102 pounds are lost in radiation.
650 pounds are lost in converting heat into energy.
76 pounds are finally converted into mechanical energy.

There is little room for congratulation that we are finally able to convert into mechanical energy less than 4 per cent of the coal mined. It is estimated that the loss due to present methods each year is greater than the mine-mouth price of all bituminous coal produced in the United States. In spite of the many improvements man has made he has a long road to travel ere his machines can be rated as efficient. Of the coal actually burned the ordinary reciprocating engine develops not more than 9 per cent of energy, the turbine engine some 12 per cent, while it is claimed that the Diesel engine will get some 36 per cent. This last engine could not have been invented before the days of metals stronger than iron and steel.

Chimneys

The old fireplace sent most of the heat itself up the chimney. The first great advance was the invention of the stove bearing his name by Benjamin Franklin in 1744. By 1752 cast-iron box stoves were on the market but the base-burner was unknown until 1830. Few people realize the extent to which stoves and furnaces have been improved by the application of recent discoveries in thermodynamics.

Engines

Modern industry is based on coal and iron but the two require the steam engine to be useful. One hundred and thirty years B.C. a mechanical genius named Hero made a little toy engine which could open and close the doors of a shrine but no special use was found for it and little advance was made until the seventeenth century. Leonardo da Vinci had constructed an engine which would roll a ball along the ground by 1480. In 1663 Edward Somerset used an engine to raise water and in 1698 a similar engine of commercial value was patented by Thomas Savery. These engines worked by creating a vacuum by pouring cold water on a vessel containing steam. About 1690 Denis Papin of France began experiments on a piston engine and this principle was the basis of the engine patented in England in 1705 by Thomas Newcomer. This engine was sometimes less efficient than hand labor and its waste of energy was the stimulus needed by James Watt to undertake the investigation which led to the discovery of the double-action engine between 1763 and 1785 which made rotary motion possible. By 1802 William Symington had constructed a tug operated by an engine and in 1807 Robert Fulton was making his world-famed trips in America. In 1829 George Stevenson built the first locomotive, "The Rocket," and began operation of the first railroad, constructed, appropriately enough, for the hauling of coal. The turbine engines date from about 1884; the Diesel engines from 1897. The best engines of 1830 burned about 10 pounds of coal per horse-power hour, ten times the amount now necessary. At the earlier date steam pressure was from 10 to 15 pounds; now our most efficient engines use a pressure of 900 or over. Compared with earlier days our present engines are not only more powerful but more efficient.

Wind and Water Power

Long before the age of coal, man had learned to use to some extent the power furnished by wind and current. He had harnessed the winds to drive his sailboats about the earth and gave them such a place in his commerce that they were not displaced until the last of the nineteenth century by the steamer. The windmill remains a useful, if somewhat unreliable, machine under conditions where absolute regularity of operation is not important. The current of the rivers has driven many wheels in many parts of earth. Until the development of electricity, water power remained relatively unimportant because man could devise no way of getting or transporting any large part of the power developed by a large stream. Even to-day man stands and watches the tides wondering how he may harness their power, yet most of the schemes suggested are futile. In one favored spot in the far northeast the attempt is now being made with much chance of success.

Electricity

Man has always known the phenomena of electricity but he saw in lightning a dangerous enemy and gained little understanding of electricity in its milder forms. A new era dawned when Franklin proved the identity of lightning and electric sparks in 1752. He and others suggested that messages might be sent over wires. Volta in 1800 finds that metals and acids will produce an electric current and constructs the first battery. About this time Oersted of Copenhagen begins the studies which enable him later on to demonstrate that electricity and magnetism are identical.

There begins too a century of wonderful advance in man's control of nature to which man in every civilized land contributed. The story is too long to be told here but it must be read somewhere by every one who wishes to understand the development of the present age. A century passes and man is sending messages over wires and through the air. The telephone, the telegraph, the submarine cable, the electric light, the talking machine, moving pictures, radio are known to all and used by all in the more favored parts of earth. Some of the great inventors like Morse, Bell and Edison are known even to the man on the street. Back of these men are a line of careful students each contributing some fact utilized by later inventors whose names are unknown save to students but to whom our debt is none the less because of our ignorance. All these industries must maintain laboratories manned by experts whose duty it is to study the problems arising and to discover ways of meeting the difficulties encountered. It is to the student of apparently useless things that the ordinary man owes all the things which make his life seem worth living.

The invention of the steam engine gave man for the first time control of great power, but this power was fixed in place and could not be moved or distributed except in railroad locomotives or other engines on wheels of limited use. Electricity made possible a new era because it could be distributed. Man began to get a new vision of his possibilities and began to dream of central systems distributing light, heat and power to the scattered households already connected by telephone lines. This general electrification is to be the work of the next century.

Petroleum

The last of the natural sources of power to be used by man was petroleum. This was known at least five centuries before Christ and was probably used in the sacred fires in the temples of Persia. Marco Polo writing about A.D. 1260 makes reference to it. It had no real use until the discovery of the oil wells in Pennsylvania in the last century. This is not surprising after all, for in few places on earth does it appear on the surface and then, as in the oil shales of the West, it seems to be of no value. Although its relationship to coal is quite uncertain it was called "coal oil" and was introduced into our lamps. At first, when distilling started, the lighter gases, such as gasoline, had little use and were almost waste products. Then a number of geniuses began to work upon the production of an internal combustion engine and the automobile industry was born. A quarter of a century passes and there are 22,000,000 cars in use in our country alone. To-day every effort is made to get as much gasoline as possible out of the petroleum. Railroad men as well as pedestrians are often in doubt as to whether the automobile is a blessing or a Frankenstein monster.

Gasoline

North America produces and uses most of the gasoline of earth. Years ago the wells of Pennsylvania began to fail and the amount now produced in Indiana is negligible. How long will the oil last? No one knows, but the world is being searched to-day for new supplies and international politics are involved. We may make new inventions such as the cracking process, without which our present supply would be inadequate. We may find new ways of getting more oil out of the ground, for the old pumping system doubtless left large residues untouched. The oil shales of Utah contain great amounts of oil if we can find some cheap method of extraction. Recognizing these possibilities it is nevertheless disturbing to have some competent authorities estimate that the oil supply of the world will be exhausted within twenty years.

Silicon

From the earth man has drawn, in addition to the metals and fuels, many other materials of great service. Silicon is not only one of the commonest elements but one of the most useful as well, although seldom used in pure state. It is due to the properties of the silicates that we are able to have our pottery and earthenware. The potter's wheel was one of man's early and great inventions and first appeared in Egypt. From the silicates we manufacture our glass, an art known to the Egyptians at least five thousand years ago. I have said glass but should say glasses for there is a vast difference in qualities between window glass and that used in optical instruments and an almost equally great difference in materials. It is a far cry from the adobe wall of the Indian pueblo to the brick baked in the oven and colored red by iron and the cement made in enormous cylinders under great heat, then ground to powder, from which we construct our concrete road or use with steel for our skyscrapers, but all are based on silicates. Thousands of combinations have been tried to find those giving us the desired qualities.

MECHANICAL SLAVES

This chapter is an extremely brief and broken sketch of the chief material elements which man has used. Save for the warning that the visible supplies of some things were decreasing there has been no effort to prophesy what the future may have in store. Man has by no means exhausted the possibilities of nature and the changes now taking place may lead into regions wholly unexplored at present. The course of human development has been away from the exploitation of goods freely offered by nature to the deliberate manufacture of the things desired by man. We still use the terms of the past and speak of candle power though candles are all but unknown to the present generation. We still measure our engines in terms of horse power. Agricultural machinery has changed more since 1850 than in all the centuries prior thereto. Man has passed from the time when he was but one of the brutes of earth to a position of mastery using the domesticated forms as his servants. With the invention of the steam engine a new era dawned. In our own day we are witnessing the shift to an era of electricity and the internal combustion engine. Tractors may replace horses in agriculture as they have in transportation. In China man power remains man power. In the United States by our use of machinery every man has the equivalent of some twenty-eight slaves working for him and magnifying the total output. Contrast this with the average of eleven Negro slaves owned by southern whites before the Civil War and remember that this was the average *per owner* and not per capita. To take but a single illustration of the difference let us remember that the grain of the world was threshed by a flail in the hands of a man until the nineteenth century. A daily average of 4 bushels per day of grain cut by hand and threshed by a flail is to be contrasted with over 200 bushels where cutting and threshing are done by machinery.

Man versus Machine

The significance of all this is that the world is being changed from a place on which man lives, helping himself from the table spread before him, to a vast laboratory in which man takes the raw materials and shapes them to suit himself. The essence of his problems is changing likewise. Now it is becoming a question what use man makes of the world. Does he create things helpful or harmful? Can he control the giants he calls into being? Does he understand what he is about and does he understand what has given him the bases of his present life? These are the questions he must answer. The problem has become social rather than physical.

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CHAPTER VIII

THE CONQUEST OF DISEASE

How small of all the ills that men endure
The part that kings or laws can cause or cure!
—POPE

THE ATTACK THROUGH THE AGES

In all ages and in all climes man has found himself the victim of the attacks of a great host of enemies, often invisible, appearing without warning, and causing suffering as well as death. If given a chance he could find shelter from the assaults of the lion and tiger but he was helpless before the "pestilence that walketh in darkness." It is a characteristic of man that he must find some answer to his intellectual problems, whether the answer be logical or fanciful. We may laugh at the ancient idea that insanity was due to moonlight but our own answer in terms of moonshine may be no better. We may smile at the interpretation of disease in terms of indwelling demons but is not the modern "malicious animal magnetism" of the same order? Job argued with his tormentors over the question of a righteous God and the existence of disease in much the same fashion as the priest of to-day. The truth is that our explanations are always a blend of knowledge and superstition, a blend in which we hope the proportion of the former is ever increasing. At all times man has known when he was sick regardless of his ignorance of the cause. So, too, he has always known whether any given course of treatment made him feel better even if he did not know whether the relief was mental or physical. Long before our records begin in any part of the world, man had found by trial and error some remedies for the simpler complaints and had developed rather elaborate methods of treatment in which he had great faith. Many of these seem foolish to us and many of our own ideas are equally foolish. Nevertheless, in no department of our intellectual life have we made greater progress than in medicine, not only in knowledge of fact but in the art as well. Our oldest records, naturally enough, are found in the early civilizations.

Early Remedies

> Before the dawn of history trephining, cupping, castration, venesection, the use of the cautery and of splints were known in many parts of the earth; though the motives that led to the employment of these practices were not in each case identical with those of modern surgery. . . . The Ebers papyrus . . . is a compilation of about the middle of the sixteenth century B.C.
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> It is in the main a collection of prescriptions, some of which had been tried frequently, as we learn from marginal notes, and found good, or excellent. It makes mention of some seven hundred remedies, evidently accumulated in the course of the ages, and put on record and preserved for posterity by the priestly scribes. Among the remedies are found poppy, castor-oil, gentian, colchicum, squills, aloes, cedar, mint, myrrh, crocus, hyoscyamus, caraway, elderberries, and many other medicinal herbs, that call to mind the therapy of North American Indians and of all primitive tribes throughout the world. The Egyptian priest-physicians made use also of certain inorganic remedies, such as lead oxide, earthy carbonate of lead, galena, meteoric iron, blue vitriol, crude carbonate of soda, sodium chloride, and sea-salt. Petroleum, bog-water, goose-oil, turpentine, ink (made from charcoal and gum), honey, probably antimony, possible mercurials, found a place in the Egyptian pharmacopoeia.[1]

In the fifth century Herodotus speaks of the Egyptian physicians as specialists.

In Babylon the healing art was also well developed and in the laws we find stipulated the sums the surgeon is to receive for the treatment of domestic animals as well as man, and, also, the penalties he is to pay if his operations did not turn out successfully. Here, too, magic and medicine are blended.

Beginnings of Medical Science

From this time on down to our own day we have a record of medical advance whose leaders are known by name and who came from all the lands and countries we call civilized. Greatest of the early Greek physicians was Hippocrates, born 460 B.C., who stressed the need of careful diagnosis and the elimination of theory and philosophy. It is significant that he should have written a book entitled *On Ancient Medicine.* He first used the words, acute, chronic, endemic and epidemic in reference to disease and his descriptions and observations will often stand comparison with those of to-day. He said that "phthisis most commonly occurs between the age of eighteen and thirty-five years." The Roman Celsus of the first century of our era first described an amputation. Galen (130-201), says Libby, "was the greatest anatomist of antiquity, and, after Hippocrates, the greatest physician."

The Nestorians carried the medical knowledge of the West to Persia before the fifth century. In one of their schools was trained the Christian Arab, Harets ben Kaladah, who became the medical adviser of Mohammed. The Persian Rhazes was called the "Experimenter." The Persian Avicennes (980-1036) wrote the medical treatise which for centuries was the standard for both East and West. The Jew, Isaac Judaeus (850-950), practiced in Egypt and Tunis. In his volume, *The Physician's Guide*, may be found such sage advice as this: "The chief task of the physician is to prevent disease. . . . The majority of diseases are cured by nature. The more you demand for your treatment and the more highly you esteem your cure, so much the higher will you stand in the eyes of the people. Your art will be held of no account only by those whom you treat gratuitously."[2] Albucasis (912-1013) and Avenzoar (?-1162) were the greatest names among the Spanish Arabs. Little by little these men, and many others including the great Leonardo da Vinci, gathered an understanding of the human body and its ailments which prepared the way for the even greater discoveries and better technique of men like the Frenchman, Ambroise Paré (1517-1590) "the father of modern surgery," and the Englishman, William Harvey, who discovered the circulation of the blood in 1616.

Galen

It is worth while to interrupt the account just here to note that the greatest genius cannot emancipate himself from the superstitions of his time. Galen was a great man but he held that the arteries were channels through which "animal spirits" entered the brain. "He talked against Egyptian sorceries and amulets, but recommended crocodile blood and a bit of peony tied to the wrist for epilepsy. He declared that he saw a boy who wore this root remain free from fits for eight months, but that when it accidentally fell off the fits returned. To prove the power of peony Galen then restored the root and the fits stopped. For the purpose of checking his results he took the root off again and the fits went on as before." Galen subscribed to the theory that certain marks on leaves or the form of roots indicated their value as remedies. Thus hepatica or liverwort was good for tumors caused by the liver, or the mandrake for debility.[3] Such beliefs are still held by thousands of folks in all lands and were the common possession of our ancestors. The bestiaries of the Middle Ages of Europe, and any study of primitive folk of to-day or any collection of popular legends will provide endless illustrations. Let us not condemn Galen too much for we follow in his footsteps. Our ancestors took over the Indian faith in kidney beans and seneca snakeroot as well as the culture of corn.

Suggested Causes of Disease

By the end of the eighteenth century the anatomy of the human body was fairly well understood. Physiology had made great advance and most of the common diseases had been described. The cause of disease was a mystery in most cases. In early time man had learned the difference between food and poison. The Egyptians had suspected that disease entered the body with the food eaten. The Israelites knew that parasitic worms (guinea worms) sometimes emerged from the body, causing intense pain, and for ages these fiery serpents had been wound on sticks and thus gently drawn from the sores. The wand with a mass of "serpents" which is the emblem of the medical service of our navy as well as that of England finds its origin in this practice. The Romans knew that insects preyed on man and suspected that they might cause disease, but as no evidence could be found the suggestion was forgotten, though revived from time to time. After the microscope revealed the existence of minute organisms previously unknown a new era dawns. By 1701 Nicholas Andry asserts that air, water, beer, sour milk, and other fluids such as the blood are filled with bacteria and that the benefit derived from using mercury in cases of syphilis is due to the fact that it kills the germs causing the trouble. Linnæus in the last edition of his great work (1768) does not know what to do with the bacteria so puts them under the heading *chaos*. Yet he had expressed himself as favoring the view that they were responsible for disease. Years were to pass ere definite evidence could be secured. The early microscopes were defective. The organisms observed were so small and so perishable that it was most difficult for investigators to get their life histories or to isolate the different varieties. Moreover, another question had to be settled.

Beginnings of Bacteriology

In spite of the acceptance of the Genesis story of creation there had survived a belief in spontaneous generation of the lower orders of life which included such organisms as insects and mice. The Italian physician Redi in 1668 had given convincing proof that visible organisms did not develop in decaying meat if flies were prevented from reaching it. The discovery of bacteria raised the issue again for what evidence could be found that these did not arise within the body by spontaneous generation. Experiment after experiment was tried with inconclusive results. Spallanzani (1729-1799) found that if he used hermetically sealed flasks and allowed them to stand in boiling water for an hour or so after filling them with concoctions of meat and vegetables that no bacteria developed. The opposition argued that in this process he eliminated the air necessary to life or had changed its quality. It became necessary to devise some way of permitting the access of air to the infusions and yet to keep out any bacteria the air might contain. By 1854 it was found that a thick wad of cotton would act as a filter. In 1861 Pasteur, who was shortly to give the death blow to the theory of spontaneous generation, devised a curved tube which answered the purpose without any filter. He then made samples of the air at various levels in the Alps and demonstrated that the fewest bacteria were found in the highest altitudes. By 1864 he could assert: "There is no circumstance known to-day that permits us to assert that microscopic beings come into the world without germs, without parents similar to themselves."

Pasteur

Louis Pasteur (1812-1895) was one of the greatest benefactors of the human race, who had, moreover, the unusual pleasure of living to see his work appreciated. Like all great scientists, he was able to use the observations and suggestions of lesser known men. It was his good fortune to live at a time when he could demonstrate some things long suspected by others and, by a happy coincidence, at a time when immediate use could be made of his discoveries. The quiet student of chemistry gave little indication of epoch-making work but his extremely careful methods of observation coupled with fearlessness when satisfied of the truth brought him deserved rewards. Long before his time it was suggested that fermentation and disease had much in common. Pasteur was able to prove that bacteria were responsible for fermentation and to find the specific bacteria in a number of cases. In 1837 the Italian, Bassi, found that a disease killing the silkworms was caused apparently by "minute glittering particles" of matter that passed from the sick to the healthy. Later the cause of a second disease was discovered. The silk industry of France was threatened by this latter, *pébrine,* and Pasteur was asked to help. He traced the life history of the bacteria, was able to isolate healthy strains of worms, and thus saved the industry. A little later (1877) he was called on to combat an epidemic of anthrax among sheep. Delafond (1838) and other observers had found a bacillus present in cases of this disease. Pasteur was able to prove that this was the causal factor and to show that if victims of this disease were buried in pastures that the germs might be brought to the surface by earthworms and thus other sheep be infected. In 1880 Pasteur discovered the cause of chicken cholera and also a way of immunizing chickens by giving them a mild form of the disease. He had long puzzled over the phenomenon of vaccination from smallpox. Could immunity be got for other diseases? The next year he was able to suggest a treatment for anthrax. Cohn (1857) had made the significant discovery that many bacteria produced spores which could withstand much exposure to heat and cold. Pasteur found that the production of spores could be prevented by growing the bacteria at given temperatures until the culture was weakened and a mild form of the disease would be produced. History shows few incidents more dramatic than the demonstration by Pasteur that anthrax could be given a chicken if its bodily temperature were reduced and that it would speedily recover when the temperature became normal. This principle he developed until in 1885 he was able to give the first inoculation against hydrophobia (rabies). At a much earlier date he had satisfied himself that disease was largely due to bacteria and that the great death rate in hospitals from operations could be lessened by greater care in the handling of bandages and in the sterilizing of hands and instruments. Not a physician himself, he effected, nevertheless, an epoch-making revolution in the practice of medicine and surgery.[4]

Koch

Meantime there was working in Germany a man who ranks with Pasteur. Robert Koch (1843-1910) attracted attention in 1876 by his studies of anthrax and by his development of a method of obtaining a pure culture of pathogenic organisms. He proved that the Bacillus anthracis was the sole cause of the disease. A few years later he was satisfied that the infections following wounds were due to microörganisms and urged the necessity of identifying and isolating them. In 1882 he made the announcement of the discovery of the bacillus causing tuberculosis. In 1883 he found the cause of Asiatic cholera and expressed his belief that insects were often carriers of disease.

The Germ Theory

At first medical men were often disposed to be skeptical about the discoveries of these last named men. Even as late as 1896, when the writer was a student at Berlin, he heard a lecture given by a so-called scientist in which Koch was condemned as having made German science ridiculous in the eyes of the world. Yet Koch imposed very severe tests upon himself and the accuracy of his studies soon carried conviction. He said that before we could be certain that a given germ was responsible for a disease it was necessary: (1) to find it present in large numbers in every case; (2) to make a pure culture of it in some medium; (3) to inoculate a subject with the pure culture and produce the disease; and (4) to find again large numbers of the germs in the inoculated subject.

To-day the scientific world does not question the belief that all diseases which can be transmitted from one organism to another are caused by some other organism usually microscopic in size. After the start was made there followed a series of discoveries of specific organisms which have been shown to be the causes of the diseases of man and of his domestic plants and animals. The list is far from complete and does not include some of the commonest diseases like measles. It may be that some of the undiscovered germs are too small to be seen with the best microscopes. Nevertheless the discovery of the nature of communicable disease has completely changed the problem. Now when we find the culprit we ask such questions as: Where does it live? Under what conditions does it increase? How does it get into the body of host?

The Pathogenic Bacteria

The original home of the bacteria seems to have been the upper inches of the soil, where they are still found in the largest numbers. As animals walked over the ground numbers of bacteria were picked up and carried on the surface of the body. Some of them found there a residence suited to their needs and remained. The host is rarely conscious of their presence nor can it be said that he is injured by them. If, however, there is a cut or accident making a break in the skin, the same bacteria may enter and cause some damage. Acne on the human skin is caused by a bacterium ordinarily living on the surface but if in any way it gets deeper into the tissues boils or carbuncles are produced which may be serious. Through food, breath, and drink other bacteria have reached the mucous membranes of the body and there reside, again doing little harm under ordinary conditions, but if there be injury or if the tone of the body be lowered, a condition favorable to their growth is produced and a cold, or pneumonia, perhaps, develops. Some of the bacteria are pus-producing if they get into closed wounds, hence the danger of all deep cuts. These bacteria which have come to live on or in any given animal will be transported wherever the animal goes. In any case there is little likelihood of getting rid of the uninvited guest. Other bacteria have a more complicated life cycle and must live for a time on the earth, or in some insect or molluscan host ere they can be transmitted to the mammal and produce disease. This is true of many parasites besides bacteria. Thus the broad tapeworm, which is rather common in folks about the Baltic, produces eggs which escape from the body of the host into running water and hatch. The young are then eaten by minute crustaceans called Cyclops (the water flea) which in turn are devoured by perch or pike. If man catches the fish and eats it without thorough cooking there is a chance for the worm to develop. In the Orient there are several flukes, related to the tapeworms, which pass from snails to crabs or fish and thence to man. Ordinarily, then, the parasitic organisms must enter the body through the nose or throat and must leave the body through the excretions. The skin is a protective covering which stops most of the enemies unless broken in some way as by accident or the bite of an insect. The germs of tetanus are common in heavily manured ground and find their way through some little break in the skin. On the other hand, the germ of the hookworm disease is able to burrow through the skin itself. It is evident that we are again confronted with the web of life and that it is to man's advantage to upset the balance of nature if he can do so. In this case the interrelations are so complex that he must know them ere his moves are likely to be effective.

It has been noted in an earlier chapter that there are certain limits to the existence of any form of life and a certain optimum under which any given form prospers. There is, thus, a geographical distribution of disease. Those bacteria which live in so far as we now know only in man or his animals, such as smallpox and tuberculosis, may be and probably will be carried wherever he goes. Yellow fever is limited to the tropics save during summer time and it was early noted that it disappeared from the United States with the coming of frost. Malaria is a serious curse from Baltimore south but is negligible north of New York City. Bacterial diseases, then, are likely to be more numerous in the warmer and moister regions of earth and to be least in evidence in high mountain countries and polar regions. This corresponds to observed facts although we should have to include density of population to make the picture wholly accurate.

The Conquest of Specific Diseases

In as much as a general survey of the problem of disease is out of the question, let us consider a few of the chief diseases of the temperate regions.

Smallpox

Fortunately for man he has been able in some cases to gain a mastery of disease without exact knowledge of its cause. The most striking illustration is smallpox. Few men of the present generation have any idea of the havoc wrought by this disease among our European ancestors nor of the danger that it presents to us to-day. Throughout the Middle Ages it killed not less than one-tenth of the entire population and few there were who escaped it during their lives, from 80 to 90 per cent having it at some time. Few even among the royal families had faces free from pockmarks. In 1722, the town of Ware, England, contained 2,515 inhabitants of whom 1,601 had been victims of the disease. An epidemic came and only 302 were left untouched. In Iceland, in 1707, some 18,000 of a total population of 30,000, or 60 per cent, died in a single epidemic. In 1752, Boston, England, had a population of 15,684 of whom 5,998 had survived an earlier attack. An epidemic came and some 5,545 contracted the disease, while 2,124 were directly inoculated with it following a custom introduced by Lady Montague in 1721. Deducting those who fled, only 174 remained who had not been sick. One-third of the passengers on the boat bringing William Penn to America are said to have died of smallpox en route. In the Revolutionary War from one-fifth to one-fourth of the army was sick at times, chiefly from smallpox. In the Union forces during the Civil War there were 12,236 cases and 4,717 deaths, a death rate of 38.5 per cent.

"A pox upon you" was one of the great curses of England in days gone by. Edward Jenner, a London doctor, having noted that the milkmaids usually had smooth faces, wondered if there could be any connection between the little sores they often had on their fingers, known as cowpox, and their freedom from smallpox. He inoculated a boy with cowpox in the year 1796 and then exposed him to smallpox. This was the beginning of vaccination and of the first great victory of man over his bacterial enemies. At this time 18 of every hundred deaths in London were due to smallpox. Ten years later this rate was reduced to 6 and in another decade to 3. Some men are mild, others are fierce. Bacteria are the same. The vaccine virus is nothing but a benignant type of the bacteria produced by breeding in a domestic animal. When transferred to man a small sore results and immunity to the later attack of the violent type is given. The results speak for themselves. In 1,166 cases of the Union men in the Civil War it was noted whether they had been vaccinated or not. Of the 679 not vaccinated 274 (40.8 per cent) died; of the 487 vaccinated 3 (less than 1 per cent) died. During the Franco-Prussian War the Germans practicing vaccination had 4,835 cases and 276 deaths; while the French army in which vaccination was neglected had 125,000 cases and 23,470 deaths. The French army, though much smaller than the German, had 26 times as many cases and 86 times as many deaths. In the World War there was not a case in the French army up to the end of 1917. Later there were 4 cases and no deaths. The British army had 12 cases and 3 deaths. The American army 979 cases, of which 241 were infected on enlistment, and 15 deaths. When the United States took over the Philippines there were about 6,000 cases yearly at Manila. Compulsory vaccination was introduced and there was not a case for seven years. Under the Harrison régime, vaccination was neglected and a marked increase in smallpox was evident by 1918. By 1921 there had been 130,264 cases and 74,369 deaths. General Wood reintroduced compulsory vaccination in 1921 and the plague was stopped by 1923. Meantime among 5,442 American soldiers in the islands there had been but 7 cases and one death. In 1920, New York, New Jersey, Connecticut and Maryland had 688 deaths while Washington and California had 9,137; that is, two western states with one-fourth the population of the eastern states had thirteen times as many deaths. The explanation is to be found in the repeal by California of the compulsory school vaccination law in 1911 followed by the repeal of all vaccination laws in 1921. California had 26,651 cases between 1919-1924 while Massachusetts had only 126. Washington repealed its vaccination law in 1919 and in 1920 had seven times as many cases as in 1917. In the epidemic at Detroit in 1924 there were no deaths among those successfully vaccinated within five years; 7 among those successfully vaccinated over seven years and 123 among the unvaccinated. Our Public Health Service reported in 1925 that smallpox had increased 75 per cent since 1923 and the deaths had increased 28 per cent. This estimate was for the world. India had the most cases but the United States had 55,538 cases in 1923-1924, about one-fifth of the world's total. We can hardly congratulate ourselves on our superior intelligence when we allow a few sincere but evidently mistaken enthusiasts to destroy our protection against one of the worst of diseases. One of our most distinguished surgeons, W. W. Keen, of Philadelphia, is the authority for the statements just made.[5]

The story is the same all over the earth. From 1893 to 1897 smallpox caused the deaths of 275,502 persons in Russia as against 274 in Germany where vaccination was compulsory. During this period Spain lost 563 per million inhabitants, Russia 463, Germany only one, and Germany has had no epidemic since 1874. In Philadelphia between 1901 and 1905 some 500 persons died of smallpox, not one of whom had been successfully vaccinated within ten years. The epidemic of 1891-1892 cost Philadelphia over $21,000,000 while the total cost of vaccination, disinfecting stations, public instruction at the same time was some $750,000.[6]

No one claims that vaccination is as pleasant as eating a dish of ice cream but the danger is not much greater. Schamberg claims that in 6,739,902 cases of vaccination there were only 476 deaths later which by any stretch of imagination might be attributed thereto, a rate of 0.007. Keen says that the records show 25,500,000 vaccinations without subsequent deaths due thereto and reports only 45 cases of lockjaw in millions of vaccinations. It happens that the writer spent some months in Haiti during a great epidemic in 1921 and had plenty of opportunity to see the situation at first hand. To see the victims sick along the roadsides, or dying in lonely cabins by the hundred; to learn that the ignorant peasants were copying the old method of vaccinating themselves from light cases, was enough to convince him that Jenner was one of the benefactors of men. Here, then, man has control, unless he stupidly refuses to learn from experience and reverts to the practice of Colonial times in America.

> Milk, being white, cured "bladder humor," and when mixed with saffron and a bit of salt could be prescribed as a cure for jaundice, for since jaundice is a yellow disease, only a yellow remedy could be effective. In New York City, apparently, the dosing had more variety, and certainly required greater ingenuity in its performance, such as catching twenty head lice and mixing them with nutmeg, sugar and a little turmerick.
>
> In cases of poisoning a black powder was the cure, and as toads were considered poisonous they were used in its compounding. Moss taken from skulls of the dead and applied to a weapon with which a wound had been inflicted, and the weapon in turn laid in the abrasion, would result in a cure. Bedbugs for obstetrical cases, and the flesh of boiled mice for timidity are but a few of the obnoxious and loathsome remedies listed in Barrough's "Method of Phesecke," and "Green's Medicine."[7]

It should not be forgotten that smallpox is kept alive because somewhere, all the time, some one has it. It may be in such mild form that it is not recognized but as it is passed along it may develop a more virulent type to become an epidemic when it reaches an unvaccinated group. A generation which has not seen smallpox is likely to become careless about vaccination. Note well that here is a case where man turns his enemy against itself and that he is unable to make any direct frontal attack on the disease.

Yellow Fever

Yellow fever offers a most interesting contrast. This fever appears to have been native to the warm shores of the Caribbean from Yucatan to Brazil and to have been carried to the western coast of Africa immediately after the discovery of America though there is a possibility that the slave ships brought it from Africa. It has never reached the Orient. It was taken by sailing ships to Havana in 1762 and was endemic thereafter. It has reached the United States a number of times, as in 1793 when 4,041 of the 40,144 inhabitants of Philadelphia died of it between August and the middle of September. The greatest epidemic was in 1878 in the southern states whose cost was at least $100,000,000 in money and thousands of lives.

Yellow fever kills about 25 per cent of the adults attacked and is usually a very severe disease, but some children and adults have very light cases. In an endemic center probably every person is attacked at some time during life and the seeming immunity of the native population as compared to immigrants is due to these light cases. The cause of the disease remained a mystery during the nineteenth century and the manner in which it reached human beings was equally unknown. It had been noted by Rush of Philadelphia that mosquitoes were very prevalent during the epidemic. A number of later observers suspected that the mosquito had something to do with its transmission and this belief grew after Manson proved in 1879 that the nematode causing filariasis (elephantiasis) utilized the mosquito as an intermediate host. By this time Finlay of Havana was convinced that the mosquito was responsible but he was unable to prove it. During the Spanish American War the American troops were rendered almost useless by disease, including yellow fever, and the medical board started a careful investigation. General Gorgas became health officer in Havana and cleaned up the city but the disease persisted. Then came the epoch-making survey in 1900 by Reed, Carroll and Lazear in which the last lost his life from the disease. They were able to prove that it was not transmitted by contact with the sick nor with dirty clothing but was transmitted by a common species of mosquito (Stegomyia) which breeds near human habitations. To-day the history is clear. Yellow fever is produced by an animal parasite which is introduced into the human body by the mosquito. If the patient is bitten in the early days of the disease by another mosquito the germs are transferred to the mosquito and after a period of about twelve days may be again transferred to man. The direct inoculation of a healthy person with blood from a patient will produce the disease but in actual life this is not likely to happen. This discovery at once changed the entire procedure. All that need be done is to keep a patient in mosquito-proof quarters and the disease will not spread.

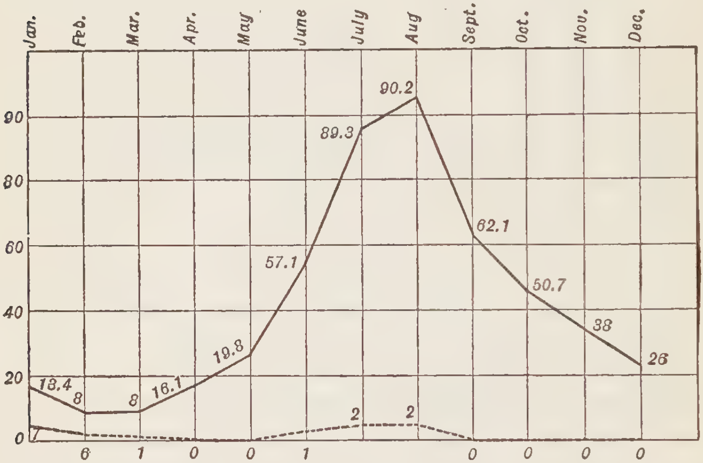

FIG. 4. MORTALITY FROM YELLOW FEVER IN HAVANA

Monthly average for 20 years preceding 1900. Lower dotted line shows 1901 mortality.

In this case a frontal attack is possible. By protecting the patients against the mosquitoes the spread of the disease is checked and by the destruction of breeding grounds the disease may be eliminated. The history at Havana is enlightening.

During the nineteenth century the deaths from yellow fever at Havana had frequently been as high as 1,500 per annum, a rate of 428 per hundred thousand population, but they

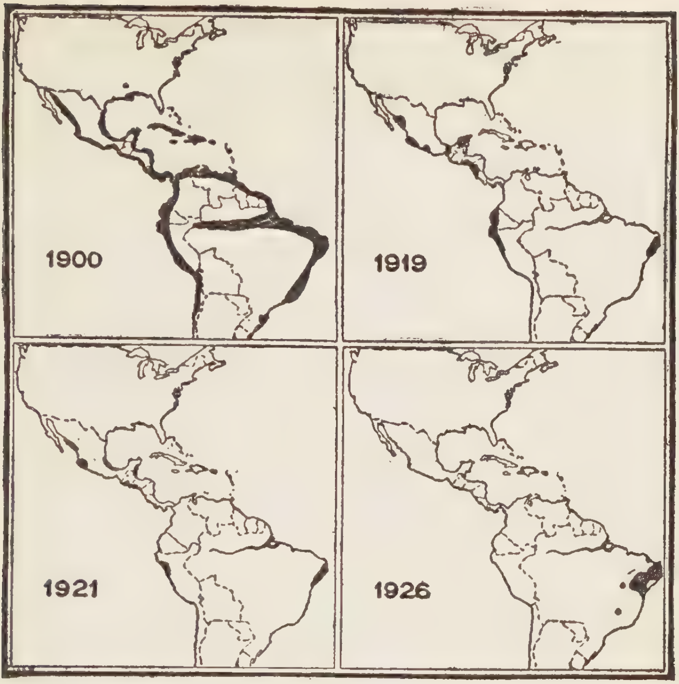

FIG. 5. DECLINE OF YELLOW FEVER IN THE WESTERN HEMISPHERE DURING THE LAST QUARTER-CENTURY

stopped abruptly in 1902, and since that date there have been but a few sporadic cases. The record is as follows:

Year	*Cases*	*Year*	*Cases*
1890	308	1896	1282
1891	356	1897	858
1892	357	1898	136
1893	496	1899	103
1894	383	1900	310
1895	553	1901	18

Gorgas was so impressed with the results that he soon suggested that similar measures should be taken for the Panama district. In 1916 he made a preliminary survey for the Rockefeller Institution of the general situation in Central and South America and in 1918 a campaign was undertaken, calling for active measures under the coöperation of local governments. Meantime Noguchi had isolated the fever germ. The success was immediate, as the accompanying chart indicates, and in 1925 only three cases were reported in the Americas. These were in northern Brazil. The fever broke out in Brazil in June, 1926, near the town of Parahyba where control measures had been stopped by the local authorities under the curious belief that they were spreading smallpox. General Gorgas died in 1920 while on his way to Africa to see what could be done there. The virtual elimination of yellow fever must be considered one of the greatest achievements of man, in part because it shows what can be done when man really understands nature.[8]

Malaria

Throughout all historic time malaria has been one of the greatest scourges of man, particularly in tropical and subtropical lands and in the moister portions of the temperate zones, decreasing in importance as the colder countries are reached, and is almost unknown in countries like Norway and Sweden. This disease is significant not only because of its share in the death rate but because of the long periods in which the patient is incapacitated for ordinary activity. It is estimated that there are from two to four thousand days of sickness for every death from malaria. When once it enters the system it may keep on recurring for months or years. The countries about the Mediterranean as well as the Caribbean and China have been hotbeds. On the island of Celebes, until 1922, it is said that "in the Dutch military encampment the brigades were often 'only able to march by combining two brigades into one.' " During the late war an observer of the troops in Macedonia wrote: "During one period more men were invalided home than arrived on ships. I heard of battalions with 75 per cent of their men on their backs and of companies in which only five men were fit for duty."[9] The experience of our men in Cuba in 1898 was similar.

Malaria is really a collective name, for there are at least three malarias now known to be caused by three animal parasites of the genus Plasmodium. The common malaria of the north, the tertian, is less serious than the æstivo-autumnal of warmer regions and yields more readily to treatment. The discovery that malaria was due to a parasite (and not to the bad air emanating from marshes as the Italians had thought) was made by a French army doctor, Laveran. Long and tedious experiments by Ronald Ross in the malarial districts of India between 1895 and 1900 demonstrated that the disease was carried to man by mosquitoes of the Anopheles type. For this work Ross received the Nobel Prize in 1902. He was in charge of sanitation at Ismailia on the Suez Canal and by his measures was able to reduce the cases of malaria from 1,551 in 1902 to 37 (all relapsing cases) in 1905.[10]

The work of Gorgas at Havana and later at Panama was equally effective. He wrote that before 1901 "Havana had yearly from 300 to 500 deaths from malaria, rising as high in 1898 as 1,900 deaths. Since 1901 there has been a steady decrease in the malarial death rate . . . until 1912 when there were only four deaths. . . . By 1912 malaria had become as completely extinguished in Havana, as had yellow fever in 1902."[11]

The efforts of the French to dig the Panama Canal were handicapped by disease more than by anything else and the chief diseases were yellow fever, malaria and dysentery. The newer evidence as to the two first diseases gave the Americans a great advantage. Gorgas sums up the situation by saying:

> We had an average of 900 men sick every day. For the year this would give us 328,900 days of sickness, and for the ten years 3,285,000 days of sickness. If our rate had been 300 per thousand, a very moderate figure compared to what it was among the French, we should have had 11,700 sick every day. For the year this would have given us 4,270,500 days of sickness and for the ten years 42,705,000, a saving of 39,420,000 days of sickness during the period.

This is equal to a cash saving of $329,420,000.

> During the ten years of construction, we lost by death seventeen out of every thousand of our employees each year. That is, from the whole force of 39,000 men, 663 died each year, and for the whole construction period we lost 6,630 men. If sanitary conditions had remained as they had been previous to 1904, and we had lost as did the French, two hundred of our employees out of each one thousand on the work, we should have lost 7,800 men each year, and 78,000 during the whole construction period.[12]

This means that 71,370 lives were saved.

Of the control of malaria, Osler has written:

> From the very outset, malaria has been taken as the measure of sanitary efficiency. Throughout the French occupation it was the chief enemy to be considered, not only because of its fatality, but on account of the prolonged incapacity following infection. In 1906 out of every 1000 employees there were admitted to the hospital from malaria 821; in 1907, 424; in 1908, 282; in 1912, 110; in 1915, 51; in 1917, 14. The totalities from the disease have fallen from 233 in 1906 to 154 in 1907, to 73 in 1908 and to 7 in 1914. The death rate for malarial fever per 1000 population sank from 8.49 in 1906 to 0.11 in 1918.[13]

The Rockefeller Foundation has also started a worldwide fight against malaria with promising results. Here again we have the possibility of destroying ultimately the Anopheles mosquito and thus getting rid of the disease which must lead a dual life, as it were, to survive. The draining or filling of the swamps and other breeding places is difficult but not impossible. Meantime it is found that large areas can be poisoned by paris green and the distribution of this by airplane has been tried. If Americans would but resolve to extinguish the Anopheles instead of the wood duck the ultimate gain would justify the effort.

Hookworm.

The surveys of the International Health Board of the Rockefeller Foundation indicate that over half of the human race who live in a broad belt ranging about 35 degrees north of the equator to 30 degrees south, are heavily infected with a third animal parasite, the hookworm, of which there are several species. Over 90 per cent of the natives of Dutch Guiana, Colombia and Ceylon are affected, while in Alabama, Louisiana and South Carolina the percentage is about 50. The disease has been known for centuries but proof that it was caused by the worm was not furnished until about 1900. It belongs to the group commonly called "filth diseases" since the eggs are passed out of the body in the excreta to hatch and live in the ground for a time. Thence they get on the feet, particularly of those going barefoot, and make their way even through the unbroken skin. In the body the worm feeds on the blood to such an extent that growth is checked and the mental energies stunned, sterility may result, and the resistance to other diseases lowered. No disease of the tropics has more serious economic consequences. In as much as the worms live in the intestinal tract of man they may be reached directly by medicine and are readily destroyed by thymol. If the excreta are cared for further infection may be stopped. As soon as the history of the disease was known preventive measures were started with the happiest of results. The percentage of school children affected in Richmond County, Virginia, was reduced from 83 in 1910 to a little over 2 in

1921. "In Costa Rica, 66 laborers before being treated for hookworm cultivated 563 acres of coffee monthly. After treatment they cultivated 750 acres. In India the amount of work increased 20 per cent on one estate and 50 per cent on another."[14] It is evident that man may win another great victory if he will persist in this campaign.

Typhoid Fever

A second "filth disease" which is of great importance is typhoid fever. It has been known for centuries, though long confused with typhus (a very different disease carried to man by the louse), but played no great rôle until about 1850. It is most dangerous where masses of people are gathered, as in cities having common supplies of milk and water or in army camps. In the Franco-Prussian War of 1870-1871 it is said that 10 per cent of the army had typhoid and that it caused 60 per cent of the deaths of the war. In the Boer War of 1889-1890, 8,022 died of typhoid as against 7,781 killed in battle. The United States has the doubtful honor of presenting the worst record, for in the Spanish War about one-fifth of our army contracted the disease and 86 per cent of all deaths were caused by it. At Jacksonville, Florida, in 1898 there were 4,432 cases and 248 deaths among 10,759 men.

The bacterium causing typhoid was found by Eberth in 1880, but the causal connection was not proved until 1900. In 1894 in Germany the first inoculations with dead germs of typhoid were given and the resulting immunity noted. It was ten years before this practice became general but it has been successful wherever tried. In our army such vaccination was optional in 1908-1909, but it was noted that proportionately about sixteen times as many unvaccinated soldiers were stricken as vaccinated. It was made compulsory in 1910 and in 1912 in the maneuvers there was but one case among 12,801 soldiers. For some nine years prior to compulsory vaccination the United States Army had about 351 cases annually, but in 1913 and 1914 there were but 4 and 7 cases respectively. American cities did not compare very favorably with the European in the years before the war. Thirty-three of its largest cities with a population of 31,500,000 averaged only 6.5 deaths to every hundred thousand while twenty-five of our cities with 20,000,000 inhabitants averaged 25.

Typhoid bacteria do not live indefinitely outside of the human body but they last a considerable time in cold water and I have seen a recent statement that they had been kept alive for two years in ice cream. They seldom increase in water but do increase rapidly in milk. Commonly they make their way to man through the milk and water supplies, though they may be carried directly to the table on the legs of house flies. In the light of present knowledge a typhoid epidemic is a disgrace. There is, however, constant danger because a few persons become typhoid carriers as the germs persist in their bodies, and thus they are a perennial source of danger. The death rate from typhoid is steadily falling. It was 37.4 per one hundred thousand in England and Wales from 1871-1875 and 2.3 from 1916-1920. In the United States it was 35.9 in 1900 and 7.8 in 1920. The Metropolitan Life Insurance Company has recently reported a decrease of 80 per cent in the deaths of its policyholders from typhoid since 1900.

Tuberculosis

Tuberculosis has long been one of the chief communicable diseases of the temperate parts of earth, though it has been important in all zones. In Europe and America it caused some 10 per cent of all deaths during the last century. Few families have been unaffected though some are more susceptible than others. There are two forms of the disease affecting man, the human and the bovine. The bovine type enters the human body largely in milk, for beef is seldom eaten raw. This type seems to attack children chiefly and probably does not cause tuberculosis of the lungs, consumption. A few experts still question the transfer of bovine tuberculosis to man but the prevalent opinion is as stated. The bacilli causing human tuberculosis are discharged into the air by the sputum of the patient and thus are inhaled by others. The bacilli will not live long in the sunlight but will survive indefinitely in dark corners of rooms, under carpets, etc. Thus tuberculosis is essentially an indoor disease and has become more dangerous as we live increasingly within four walls. It is likely that most of us have it at some time during our lives for few can escape contact

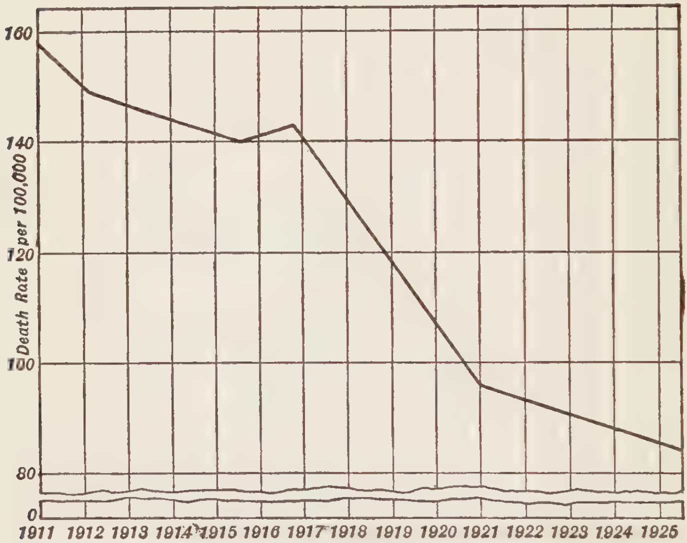

FIG. 6. DEATH RATE FROM TUBERCULOSIS IN THE UNITED STATES REGISTRATION AREA

Death rate per 100,000: 1911, 157.6; 1925, 86.7.

with it. It is not incurable and yet there is no cure for it. If taken in time a patient will probably recover if freed from undue work and worry and given plenty of food and sunshine. The antituberculosis movement is one of the best organized of our social campaigns and the death rate from the disease is about one-half of what it was in 1900, as the chart (p. 226) indicates. It now stands sixth or seventh among the causes of death in our country. We have found no specific remedy nor have we found any serum which gives immunity or relieves an attack. Yet in 1912 Earl Mayo could write: "If the members of the medical profession were given a free hand to deal with this disease, backed by adequate provision, for the care of existing cases, tuberculosis could be practically stamped out within a single generation." [15]

Cholera

There are two other diseases which might sweep over this country as great epidemics, both of which find their original home in Asia. Cholera, caused by the comma bacillus, is endemic in the valley of the Ganges and has been carried elsewhere by religious and other pilgrims. In the year 1885 it took a toll of 100,000 lives in Japan and caused a money loss of not less than $200,000,000. It has invaded Europe several times, the last being the epidemic at Hamburg in 1892 which destroyed 8,000 lives and cost some $25,000,000. This is thought to have been started by emigrants from Russia on their way to America but temporarily detained in Hamburg. In 1912, in the four days ending December 27, cholera is said to have killed 1,714 persons in Mecca, with some 10,000 pilgrims present at the time.[16]

Bubonic Plague

The bubonic plague has invaded America several times and there is some danger that it may find a permanent home here. Under the name "black death" it swept Europe in the fourteenth century, killing some 25,000,000 people, or one-fourth of the total population. In Manchuria in 1911 some 50,000 died of it in three months; every person stricken dying so far as is known. The bacillus producing this disease was isolated by an American, R. P. Strong. The bacillus lives in a little fur-bearing animal of Manchuria, the tarbagan, often hunted by the Chinese. If it reaches the lungs of a person it produces what is called the pneumonic plague, almost invariably fatal. Ordinarily it is transferred to man by the flea, resulting in the bubonic form. This disease was brought to San Francisco, probably by rats escaping from ships in the harbor, in 1909. In spite of considerable local opposition because of the alleged unfavorable advertising it caused, the United States authorities were able to check it promptly by destroying the local rats. The disease has reappeared since that time in New Orleans, Los Angeles, and Oakland. There is reason to fear that it may find a congenial home in the countless ground squirrels of California, and the victims of the last attack at Oakland appear to have been Italians who had been hunting these squirrels. In as much as we are aware of the danger it should be possible to avoid serious results. A serum has been found which gives considerable immunity against the disease.

Anæsthetics and Germicides

Nitrous oxide was discovered in 1774 and its anæsthetic properties were soon recognized. By 1800 Sir Humphrey Davy used it on himself and in succeeding years a number of physicians employed it successfully. After Morton gave a public demonstration at the Massachusetts General Hospital in 1846 it was generally adopted and thenceforth surgery ceased to be torture. Medical and surgical practice developed rapidly during the first half of the last century and hospitals came into favor. Unfortunately the gathering together of the sick and injured favored the spread of various bacteria whose presence was hardly suspected, with the result that hospital operations were accompanied by a high mortality rate. This attracted the attention of many physicians, among them Lister, who sought some solution. In 1865 he began the use of carbolic acid and obtained such excellent results that he called the attention of the profession to his success. The necessity of a change is shown by the results of an investigation made in 1869. Out of 2,098 amputations in country practice, 226 had proved fatal, but 2,089 hospital amputations showed 855 fatalities. The investigator, Sir James Simpson, said: "Most hospital surgeons ever remain content with losing one-third to one-half of all their amputation cases, and nine-tenths of some."[17] The French hospitals during the Crimean War had a frightful record. "Out of 13,173 amputations of all kinds, including those of fingers and toes, 10,006 proved fatal."[18] Lister early learned of Pasteur's studies on fermentation and putrefaction and became an enthusiastic supporter. Lister's fame spread rapidly. The German surgeons sent to him for aid. A new era dawned and the contrast is best shown by a little table:

The mortality of ovariotomy, formerly 60 per cent, is now 2-3.

The mortality of compound fractures, formerly 60 per cent, is now 3.

The mortality of major amputations, formerly 50-63 per cent, is now 10-20.

In 1870 all openings of head, chest, and abdomen were considered almost necessarily fatal and were only made when death was otherwise certain. Now they are practically without danger. The old death rate in hospitals of women at time of childbirth was alarming. From 1803 to 1833 the Pennsylvania Hospital had a record of 5.6 per cent. In an epidemic at the Bellevue Hospital in 1872 the death rate rose to 18 per cent. When it was discovered that this was due to bacterial infection improvement was possible. By 1909 the New York Lying-In Hospital reported that only 0.34 per cent of 60,000 obstetrical cases were lost, or one out of 1,250. In good hospitals to-day the loss does not exceed 0.25 per cent.[19] Knowledge of the minute forms of life and the means for their control has made man master of the situation.

Space limits prohibit detailed consideration of other diseases and the treatment now given them. This chapter makes no pretense of giving a summary of disease. The illustrations have been chosen to show man's relations to other forms of life and the advance made possible by understanding these relations. Incidentally they show most of the methods employed in fighting the disease, and some of the dangers involved in migration and commerce. Man must eat the lower organisms in order to live. He must also prevent them from eating him, and this is much more difficult. Formerly man feared the bigger animals, now he must devote his attention to minute enemies. It requires brains to fight invisible enemies. Can the man in the street be educated to the point where he will follow trained leaders? The problem of health has become social rather than medical. We must turn from the doctor with "his pill for every ill" to the sanitary engineer and must be willing to pay the doctor for keeping us well rather than for curing us after we are sick.

It will have been noted that few specific remedies have been found for diseases. Quinine will kill the germs of most malarias but it is better to kill the mosquitoes. Iron attacks anemia. Mercury and arsenic are fatal to the germs of syphilis. Chaulmoogra oil appears to be working wonders for the victims of leprosy in the colony at Culion. We may hope for the discovery of other specifics but in most cases we must turn the enemy against itself as in typhoid, smallpox, diphtheria, and tetanus.

THE DEATH RATE

The results of all this newer knowledge are shown by the steady fall of the death rate in civilized lands. In 1875 the death rate in New York City was 28.3 per thousand; in 1925, it was 11.5, a reduction of 59.4 per cent. In 1868 the death rate for children under five was 124.8 and in 1920 it was only 30.8. By contrast the death rate in 1868 for the age periods forty-five to fifty-four was 22.1 and in 1920 it was 32. For a good many years the Metropolitan Life Insurance Company has conducted a campaign of health education among its policyholders. The results since 1811 are almost astounding. The reduction between 1911 and 1925 was 56 per cent for tuberculosis, 80 per cent for typhoid fever, from communicable diseases of childhood 55.5, from diphtheria 62. The downward trend of the death rate in the registration area of the United States is shown in the following diagram, which reveals a drop from 10.1 in 1911 to about 8.6 in 1926. The sharp rise in 1918 and 1919 was due to the epidemic of influenza.

Striking as these figures are it will be noticed that the chief reduction is in the case of children. As we raise the average age of the population we must expect an increase of deaths in the later years. This may be in part the explanation of the increase of cancer, which is rapidly rising to the top of the list, a disease, moreover, whose cause is unknown. Degenerative diseases are becoming more common also. "The real risk of dying from cancer increased from 4 to nearly 60 per cent at various ages for males and from about 18 to nearly 70 per cent for females between 1910 and 1921. The heavier increases at the later ages affect, however, only a small number of lives exposed in a life table population."[20] It is claimed that over 30,000 young men and women between the ages of twenty-five and twenty-eight die each year from preventable causes in the United States.

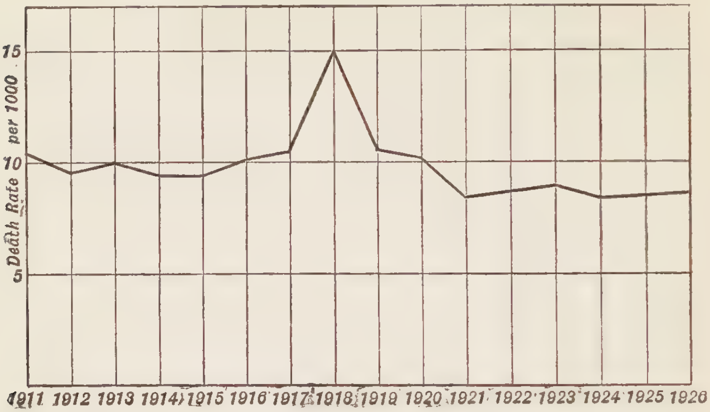

FIG. 7. DEATH RATE FROM ALL CAUSES IN THE UNITED STATES REGISTRATION AREA

Increase in Life Span

Possibly a better way of estimating the advance we have made is the increasing length of life. In 1880 the average life of a citizen of New York was about forty years, now it is fifty-five or fifty-six. In 1901 a baby born in the United States might expect a life of 49.24 years, now the expectation is 57.32. It is claimed that the average length of life in Europe in the sixteenth century was eighteen to twenty years, whereas as many people now live to be seventy in Geneva as lived to be forty at the earlier period. Sweden shows an addition to average life of fourteen and one-quarter years in the last ten decades. When accurate statistics were first kept in England only 31 per cent reached the age of sixty-five, now some 47 per cent are said to attain that age. In India, by contrast the average age at death is said to be twenty-three for men, and twenty-four for women, with little change in recent decades.

This saving of life means also a decrease in number of sicknesses and a consequent improvement in regularity of work and in productiveness. While man has not solved his problem of disease he has greatly improved the conditions of life and may expect even better things in the future, *Provided.*

Plant and Animal Diseases

The increasing dependence of man upon domestic animals and cultivated plants makes the problems presented by their diseases hardly less important than his own health. There are two reasons for this. First, disease may reduce the amount of his products or injure their quality, and, second, the animals may be intermediate or alternate hosts of diseases to which man is liable. In as much as the treatment of these diseases introduces no new principles, no extended discussion is necessary. About the only differences observable are that the animal cannot lie to the doctor and that man is more interested in preventing the spread of plant and animal disease than in curing the sick individual.

Diseases of Plants

All cultivated plants are attacked by various fungi, some native, some imported. The cost to man runs into enormous figures. Only by exercising the greatest care can the greenhouse manager prevent plant disease. Sometimes the fungus attacks one type of plant, sometimes it spends part of its life cycle on one host and thence makes its way to another. The white-pine blister rust which threatens our native pines was widely established in the East by 1916 and had been carried from France to British Columbia by 1910, thence spreading on the north Pacific coast. This fungus requires some intermediate host like the gooseberry, black currant, barberry. Only by eliminating these shrubs can we save the pines. The rust infection of spring wheat in

North Dakota in 1924 was traced to barberry bushes near Jamestown. So the stem rust on oats in Wisconsin was traced to barberries. Disease reduced the 1922 crop of potatoes and sweet potatoes about one-fifth. Peach orchards have been destroyed by the "yellows." The pear blight has often been serious. This is a native disease which we have exported to New Zealand. Our early attempts to grow grapes were often ruined by black rot and downy mildew. Again, we must remind ourselves that nature is unmoral, for fungi often attack and destroy insects.

Diseases of Animals

Domestic animals suffer from many diseases. Chickens are attacked not only by diseases which may spread rapidly in large flocks but which may sometimes be a threat to other animals. Thus there is an avian tuberculosis which often attacks swine, rendering them unfit for human consumption. In 1926 some 6.2 per cent of the chickens inspected in thirty-six states were tuberculous. Pig tuberculosis seems to be increasing and the pig appears susceptible to any type of tuberculosis. From the rat the pig gets the trichina which it may pass on to man. Hog cholera is the most serious disease of swine. "During the last four decades hog cholera has caused in this country animal losses ranging between $13,000,000 and $200,000,000, killing annually an average of 66 out of every 1000 hogs."[21] It has destroyed 130 out of every thousand swine in a year, appearing in great epidemics in 1887, 1897, 1913 and 1926. The losses of animals in nonepidemic years have often reached 3 or 4 per cent.

Tuberculosis is the greatest prevalent enemy of our cattle. Not until about 1895 was it realized that bovine tuberculosis was a problem serious to man as well as to cattle and only in the last decade has a well directed campaign arisen. The distribution of this disease shows geographical differences as it hits the dairy herds more than range stock. In 1926 some 2.8 per cent of our cattle were tubercular but in some sections not over 0.5 per cent were affected while in others 23.6 were diseased. Individual herds have often shown a much higher rate. About 63 per cent of our dairy cattle and 36 per cent of the beef cattle were under supervision in 1926. The sickness rate is showing a steady decline as supervision increases.[22]

Cattle are subject to the attacks of epidemic diseases like the "hoof and mouth" disease which swept over sixteen counties of California in 1924 and resulted in the destruction of 58,791 cattle, 21,195 hogs, 28,382 sheep and 1,391 goats—a total of 109,766 domestic animals, not to mention 22,214 deer in the Stanislaus National Forest to which the infection spread. In some sections great trenches were dug by steam shovels and the cattle driven into them for destruction. The loss was estimated at over $7,000,000. Later in the year there was a small outbreak in Texas, seemingly of separate origin. The California outbreak is believed to have started in hogs fed on refuse from Mare Island Navy Yard which contained some imported carriers of the disease.[23]

Horses suffer from glanders and influenza and are not immune to tuberculosis. Dogs and cats suffer from rabies, which is very dangerous to man. Sheep are attacked by anthrax.

Now that the nature of disease is fairly well understood the state and national government are coöperating to prevent the importation of disease carriers and to stamp out any infection that may appear. Gradually the producer is learning that safety depends on eternal vigilance. Probably in no other field has control of nature been of greater help to man. Even so we stand at the beginning rather than at the end of our development.

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CHAPTER IX

POPULATION AND THE FOOD SUPPLY

> We look for rams and asses and stallions of good stock, and one believes that good will come from good; yet a good man minds not to wed the evil daughter of an evil sire if he but give her much wealth.—THEOGNIS, VI CENTURY B.C.

THE WORLD POPULATION

In all ages and climates mankind has observed the Biblical command, "Increase and multiply," more willingly and more uniformly than any other. We do not have detailed information for the entire world. Outside of a few countries all statements of population are estimates and many are crude guesses. All students agree in the belief that there has been an enormous increase during the Christian Era and that the net increase was greatest during the last century. A world population of some 850,000,000 in 1800 had doubled by 1900 to at least 1,750,000,000. To this there has been added yearly not less than 12,000,000, so the present total cannot be far from 2,000,000,000. If this rate were to continue there would be 5,000,000,000 human beings on earth by the year 2000, and 17,000,000,000 by 2100. Rossiter has estimated that the white races alone increased from about 30,000,000 in A.D. 1000 to 210,000,000 in 1800, but leaped to a total of 645,000,000 by 1915.[1] If this rate were to be continued to 2020 the descendants of the European stock would number 1,980,000,000—approximately equal to the present population of earth. At the present rate the population of continental United States will double in fifty years, without any immigration, and Pearl estimates a total by 1980 of 175,000,000. The nineteenth century, then, was the era of the most rapid increase in numbers of men as well as that of the greatest advance in the technical arts. Whether or not these are related phenomena remains to be seen. In an earlier chapter we saw that the increase of any form of life caused certain problems; compelled some readjustments. How, then, did man provide for the needs of all these added millions?

Population Movements

One has but to compare the scattered population of Colonial days in America with the present population (1920) per square mile of Massachusetts (479), New Jersey (420), or Rhode Island (566), to realize that increased concentration has taken place. But we must not assume that this concentration is uniform. What has happened, in part, is a movement away from the farms to the industrial centers. In 1880 the rural population of the United States was 36,000,000; the urban, 14,000,000. In 1920 the rural population was 28,000,000; the urban 90,000,000. The actual farm population in 1910 was 12,659,000 but in 1920 it was only 10,953,000. There are agricultural counties which have not gained in population since 1870 and one-third of the counties of the country actually lost in population between 1910 and 1920.

This shifting of population has not been limited to our country. During the last century there was a steady movement away from the older centers of culture to new and relatively unoccupied areas. In reality this was the greatest era of wandering known to man. The population of Canada increased from 251,000 to 5,370,000—some twenty fold. That of the United States increased 35 per cent per decade down to 1860. From 1820 to 1900 some 18,650,335 immigrants landed on our shores and not less than 16,000,000 have come since 1900. In spite of this vast migration to new lands, the older countries, with few exceptions, have not lost, but on the contrary, have gained in population. Thus Great Britain and Ireland increased from about 16,000,000 in 1801 to 41,000,000 in 1901. A great civilization has sprung up in Australia and New Zealand. Buenos Aires is the third largest city in the Western Hemisphere. To-day the situation is changing. There are few unoccupied areas tempting to men of the temperate zones and most of these are well organized politically and controlled by people not friendly to mass immigration. To what place is the surplus population of this century to migrate?

Resources and the Standard of Living

Two entirely different questions are coming into the foreground. The first deals with the adequacy of natural resources to meet human needs, the second is the question of the standard of living. That these questions are related is obvious. That this relation is not fixed and final, but relative and changing is equally clear. We may state it in this fashion: What is the effect of an increase of population on the standard of living? This question leads to another: Which does man consider more important, the raising of the standard of living, or the increase of total population?

The optimist often states these fundamentals as if nothing more were involved than the problem of securing food and clothing from an inexhaustible storehouse for a constantly increasing population. He is satisfied that, in some way or other, "the Lord will provide." By contrast the pessimist, impressed by the shortage of some commodity such as wool or gasoline, stresses the early end of our culture. In reality the problem does not lie in the relationship of a number of fixed quantities but deals rather with many variables. For illustration, if we were to assume that bread was the staff of life, it would not be difficult to tell how many persons could be fed from the product of a given number of acres worked under given conditions by a given labor force. But the problem is more complex. Man's standard of bread may change. It was one thing a generation ago. It is far different to-day when man demands a fine white flour with the result that about one-fourth of the wheat is turned into bran, one-fourth into shorts, so that only one-half of the wheat enters human food, and this half has lost much of the food value of the whole wheat. Elsewhere man has demanded polished rice, and has got it—has got beriberi also. Illustrations are easy. But who can state or fix limits to human demands, or tastes? As a matter of fact, man's standard—that which he demands, not what he wants—ranges from the mere existence level of folks situated as are the Eskimos or most of the Chinese, to the relatively high levels of a fortunately situated people, the Americans. Any discussion, then, of the growth of population must deal with the standard of living if it is to have any real value or meaning. Between the mere existence *minimum* and a relatively rich *maximum* there is a wide range of choice. The question is not how many men earth can support, but under what conditions do men prefer to live.

The Cause of Migrations

A further complication is caused by the rivalry between different races of men for the control of desirable parts of earth. The politician, thinking in terms of supremacy over other groups, of conquest, has always favored an increase in numbers that his nation might have plenty of "cannon fodder" in times of war. Do not blame the politician. He is but the mouthpiece of the great inarticulate mass of common men behind him. Germany's old demand for a "place in the sun" meant, in reality, a location for surplus population. The antagonism to "perfidious Albion" was founded on jealousy, not on condemnation of England's policies. Neither Japan nor Italy are, or can be, satisfied with the immigration policies of Australia and America. Suppose other nations followed suit and no place were left for surplus populations! He reads history blindly who does not see that the increasing difficulties of maintaining old standards at home has been one of the greatest causes of human migration, whether the causes back of the difficulty were changing climatic conditions or something else. The normal movement of men, then, is from a place where old standards are becoming difficult to a place where they, or even higher, standards, may be maintained. The primary appeal of the frontier as a place of permanent residence is only to those who think in terms of future welfare. The change in American immigration policy from the welcome extended to strangers which characterized the last century to the exclusion policy of to-day is based, in part on racial jealousy to be sure, but chiefly on the fear that the incoming hordes will lower our standard of living. This suggests that the era of great peaceful migration is drawing to a close. It would appear that in the future the statesmen of the world will have to find local solutions of their population problems or else embark on an era of wars which will dwarf earlier wars into insignificance. Is the League of Nations ready to consider such questions?

The continued prosperity of man on earth depends on:

1. Amount of agricultural land
2. Supplies of metal and other necessities
3. Sources of power, coal, electricity, etc.

Any improvement or increase of supplies depends on:

1. Additional land secured by drainage, irrigation
2. New sources of metals, fuels, etc.
3. Technical improvements in machinery and methods
4. Plant and animal breeding
5. Increased use of ocean's products
6. Elimination of waste (really a part of 3)

THE PROBLEM DEFINED

With few exceptions prior to the last century the men whose ideas have come down to us never viewed the growth of human population in terms of world conditions. This occasions no surprise, for their ignorance of the earth as a whole made such discussion impossible. The local problems were often considered, and scattered over earth we find such social policies as the destruction of infants or the aged practiced and defended on grounds of group necessity. The world, however, seemed so vast that migration always offered a solution. Sir Thomas More in *Utopia* had raised the question of population and such men as Montesquieu and Benjamin Franklin had appreciated its importance. The common idea of the last of the eighteenth century was presented by an able English writer, William Godkin. "Three-fourths of the habitable globe is now uncultivated. The parts already cultivated are capable of immeasurable improvement. Myriads of centuries of still increasing population may pass away, and the earth be still found sufficient for the subsistence of its inhabitants." [2]

Malthus

It remained for an English preacher, Malthus, in his *Essay on the Principle of Population* in 1798, to state the question in such a way as to attract immediate and lasting consideration. It is doubtful if any other thesis of similar age is more energetically opposed or defended to-day. Much of the current discussion is useless and sterile because dealing with single phases of the topic or with part truths. The popular statement of the Malthusian Law, "Population tends to increase in a geometrical ratio while food supply increases in an arithmetical ratio," literally taken, is foolish, but taken as a figure of speech it is profoundly true. It is interesting and significant to discover that natural scientists and economists agree with Malthus almost to a man, while his opponents are men in business or public life. What, then, are the facts at present? In the following pages I shall draw freely from an outstanding recent work on population, *Mankind at the Crossroads,* by E. M. East.

East's Summary of the Present Situation

There are on earth, according to East, some 13,000,000,000 acres (40 per cent of the land area) available for agriculture. On the basis of the best prewar European agriculture about 2½ acres of cultivated ground are required for each person to be supported.[3]

Countries	Tilled per Capita	Per Cent of Population Supported	Acres per Person Supported
Germany	1.15	72	2.
France	1.50	70	2.3
Italy	.98	64	2.4
Belgium	.37	37	1.7

The production in these four countries has averaged 70 per cent above that of the other advanced nations, according to the computations of the authorities in our Department of Agriculture.

INDEX NUMBERS OF PRODUCTIVITY PER ACRE[4]

Belgium	221	Austria	120
Holland	190	Hungary	113
United Kingdom	177	United States	96
Germany	169	Italy	96
Denmark	168	Rumania	94
Japan	137	Spain	93
Canada	136	Australia	76
Chile	136	Argentina	71
Sweden	128	Russia	71
France	123	Mexico	62

If all the available land on earth could be cultivated in accordance with that of the best countries, a total of 5,200,000,000 persons could be supported on a basis equal to that of prewar Europe. It has been indicated that this total population may be reached in a century. The annual increase of population demands some 23,000,000 pounds of additional foodstuffs, or the product of 30,000,000 extra acres of land. Whence is to come this extra land? East makes a survey and we can do no better than follow him.

In 1920 Japan supported about one man per acre of cultivated land, or about 40,000,000 of her 56,000,000, importing food for the rest. To raise this amount she used the enormous total of 4.5 tons of fertilizer per acre. The unused land is so poor that any great extension of acreage is impossible. But the Japanese food standard is only about one-half that of America. In other words, Japan would be able to support only 20,000,000 people on the American standard.

During the war the Food Committee in England showed that the food production from 1910-1914 was about 41 per cent of the total needed. "They were able to supply themselves with vegetables, with 60 per cent of the meats, with 68 per cent of the eggs, with 36 per cent of the fruits, but with only 20 per cent of the wheat and animal fats." East believes that the total maximum possible production is not over 60 per cent of England's needs.

Switzerland is able to cultivate only 3.5 per cent of her area while Spain and Portugal cultivate about 30 per cent. In these lands food importation and exportation about balance. In the last two improvements in agriculture might make a 50 per cent increase in population possible.

Prior to the war, Russia, Rumania, Bulgaria and Servia might be compared to the United States of 1880. Food was exported. The population was increasing. Some increase in total population is possible along with improvements in agriculture.

East, with such men as Secretary Hoover and many European students, holds that the balance of western Europe from Sweden to Italy is overpopulated and cannot support the present population, with the Scandinavian countries forming a possible exception. This means that food must be imported in large quantities. This is now coming from Canada, United States, Australia, South America. Whence are supplies to come in the future as these lands cease to export food?

The Australian population is doubling in about thirty-four years. Only about 1 per cent of the land is cultivated, some 19,000,000 acres, and it is doubtful if over 40,000,000 acres can be cultivated. The indications are that Australia will need all the food it can produce in twenty-five or thirty years.

The Canadian population was over 8,000,000 in 1926. Canada may perhaps support 60,000,000. At the present rate of increase this figure will be reached before the year 2000.

Argentina and Uruguay cultivate only 62,000,000 of a possible total of 350,000,000 acres. The present population is about 10,000,000 and a total of 140,000,000 is possible, allowing 2½ acres per capita. If the increase of population is steady it is doubtful if much food can be spared fifty years hence.

China and India as well as Japan are frightfully overpopulated (153, 148, and 312 respectively per square mile) and in the first two the population is practically stationary. On the Japanese basis the Malay area might support 200,000,000 or twice its present number of inhabitants. Huntington has recently called attention to the fact that Java with an area about equal to Iowa has a population of 35,000,000, equal to 700 per square mile; that it imports about 150 pounds of rice per family each year; that it may export rubber and other commodities.[5]

East holds that tropical America may some day support a maximum of 300,000,000 but the future of the tropics is uncertain. Africa seems to be the only other place where marked increase is likely and a great civilization may some day be located in the central highlands.

East summarizes his observations in the following paragraph:

> Temperate Europe and Asia taken as a whole are over populated. Only Russia can take care of many more people. Tropical Asia is in the same situation with the exception of some of the islands of the Malay Archipelago. The remaining tropics are undermanned from the view-point of a high civilization, but most of the peoples now inhabiting them are increasing slowly because they have reached the barriers shutting in their particular race and social status. The European countries are increasing rapidly, not because they have any more room in their home lands, but because industrial expansion permits it, through the fact that there have been and still are undermanned countries suitable for extensive agriculture giving large returns per capita and small returns per unit of land to any efficient, energetic people. These countries are North America north of the Rio Grande, the lower parts of South America and Africa, and Australia and New Zealand.[6] . . .
>
> European colonization of the real tropics will not come until dire necessity forces it under any circumstances. It will not come until population pressure is severe in all temperate countries. This gives a respite of less than half a century at present rates of increase, of less than a century at the rate of increase which probably will ensue during that time, and throughout most of the period the severity of the struggle in these countries will be marked. Utilization of the high tablelands of Africa seems the only solution of the overflow during this period.[7]

In spite of all possible improvements in agriculture, in breeds of stock, in mechanical and technical advance, East believes that the world will be filled to the limit in less than a century. If the present population doubles we shall approximate the condition of China and India.

THE SITUATION IN THE UNITED STATES

The situation in the United States is deserving of more detailed consideration and the evidence will be drawn largely from a series of very valuable articles in recent *Yearbooks of the Department of Agriculture,* particularly that for 1923.[8]

In this country there are about 1,900,000,000 acres of land of which in 1919 some 879,000,000 were included in farms (46 per cent) and 478,000,000 (26 per cent) were cultivated. The harvest in that year was gathered from 365,000,000 acres. Theoretically some 600,000,000 acres more can be cultivated. Much of this is stump land involving heavy costs for clearing. Much is light soil not suited to grain but adapted to fruit or cotton. To make the estimated total some 68 per cent of the swamp land would have to be cleared and drained. Shortage of water prohibits the reclaiming of more than 30,000,000 acres (8 per cent) of the western desert. As a matter of fact, both here and in Australia many of the irrigation projects have been disappointing. Baker[9] estimates that the maximum possible increase of tillable land is not over 250,000,000 acres (47 per cent) of our present improved acreage.

Of the cultivated land only 20 per cent was devoted to human food, 10 per cent to materials for industry, and 70 per cent to forage crops for animals. There are about a billion acres of pasture lands of which over one-half is so poor or arid that it furnishes only one-sixth of the feed needed for livestock. Regardless of future improvements all the good land of the United States is in use and the cost of reclaiming the rest will be greater than the value (per acre) of cultivated land only a few years ago.

The following diagrams show the situation:

In addition to the 365,000,000 acres of land in harvested crops in 1919, it is estimated that there are also about 600,000,000 acres physically capable of being utilized for crops some time in the future. This includes practically all of the land that is not too rough, rocky, sandy, cold or dry, or that is not now employed for uses other than agriculture and forests. Consequently it includes some land that it will not be economical to reclaim for crops even when we reach our maximum population. It also makes no allowance for pasture, except semiarid pasture too dry for crops and a small amount of humid pasture too rough for cultivation, nor for land needed for the expansion of urban areas, roads, railroads, etc. Undoubtedly a part of this potential crop area will always be employed for pasture.[10]

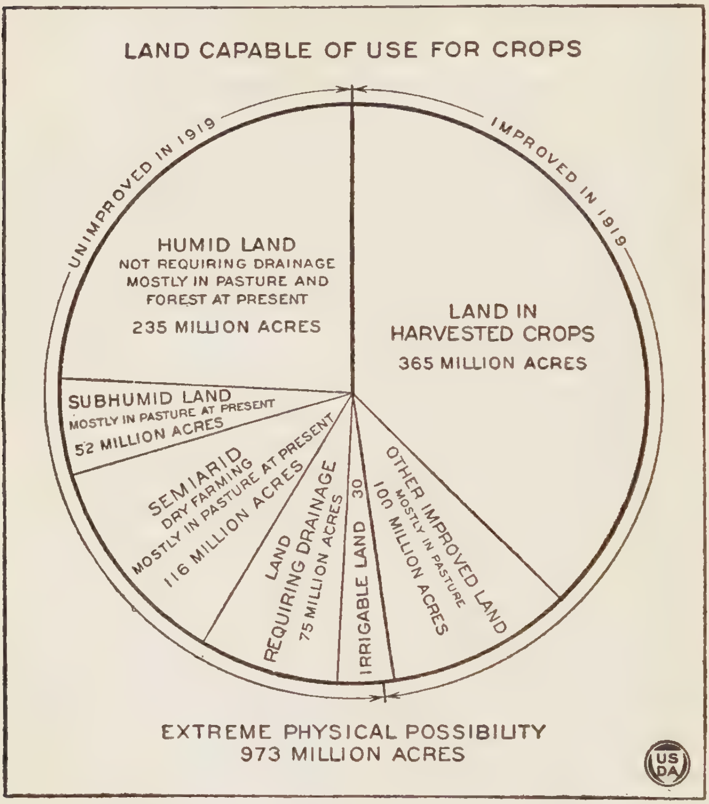

FIG. 8. LAND CAPABLE OF USE FOR CROPS

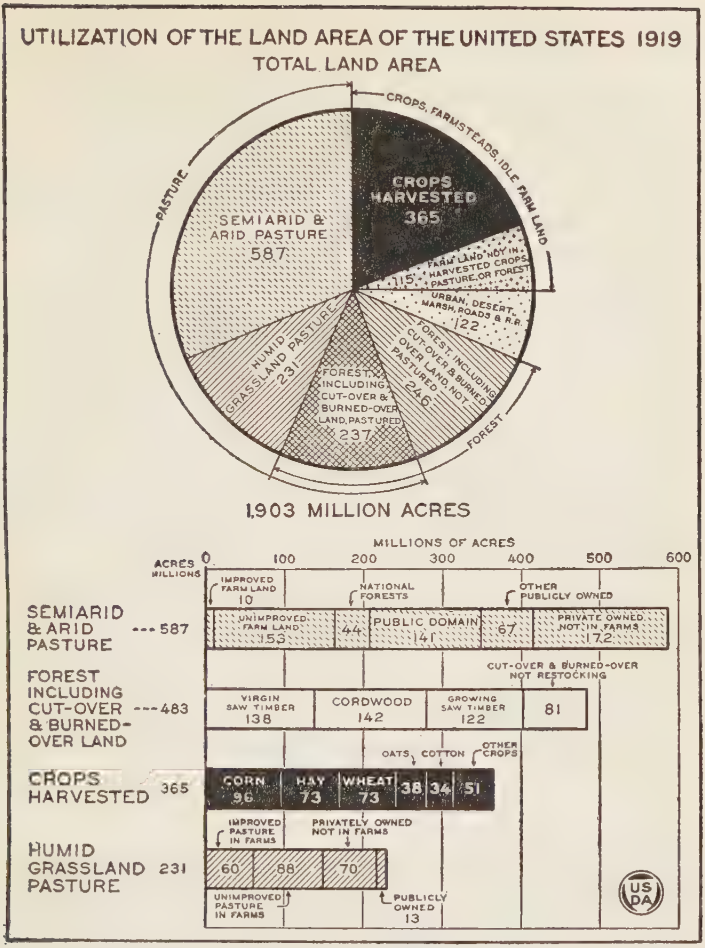

FIG. 9. UTILIZATION OF THE LAND AREA OF THE UNITED STATES [11]

Our Food Supply

Taylor in a very valuable survey entitled, *Agriculture and Population Increases,*[12] thinks that we shall be able to produce adequate food to provide for the estimated population of 175,000,000 in 1980, provided some improvements are made as well as some changes in diet. He visualizes the domestic animal situation somewhat as follows:[13]

Supply	Milch Cows	Beef Cattle	Hogs	Sheep
Present	25,000,000	67,000,000	63,500,000	40,000,000
Future	29,000,000	79,000,000	66,000,000	70,000,000

Present and future consumption of meat as compared with that of prewar Europe is shown below, in pounds per capita:[14]

Country	Beef	Pork	Mutton	Total
United States { present	68	90	6	164
United States { 1980	50	64	6	120
United Kingdom (prewar)	64	40	29	133
Germany (prewar)	38	74	3	133
France (prewar)	47	37	7	91

Horses we shall regard as constant, since against the future enlargement of acreage we may set the future development of mechanical traction. Probably 5 million more cattle and 40 million more sheep would be required; the count of swine would remain the same. As efficiencies are attained, the per capita figure for animals will decline.

Each animal unit [animal unit equals 1 head of horses or cattle, 1 of hogs, 12 of sheep] now requires about two acres in harvested crops. Twelve million additional animal units would therefore represent some 25 million additional acres at present yields; but with a 10 per cent increase of efficiency of yield in

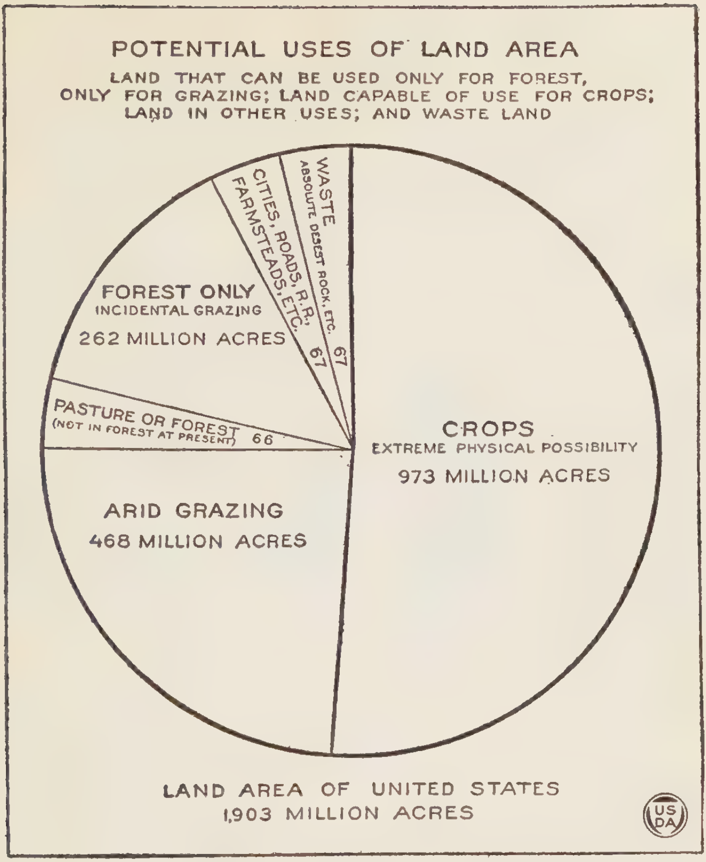

FIG. 10. POTENTIAL USES OF LAND AREA OF UNITED STATES[15]

Land that can be used only for forest, only for grazing; land capable of use for crops; land in other uses; and waste land.

the next fifty years, the acres now devoted to animals would carry the estimated number.

The additional acreage necessary for the additional wheat, coarse grains, and other primary foodstuffs previously discussed, could not be over 25 million acres. With increase in yields of 20 per cent in the next fifty years the projected population could be carried on the present acreage.[16]

Fifty million acres must be added then, for harvested crops, and this Taylor thinks is easily possible. In as much as he is one of our best authorities on food his conclusion is doubly significant: "When the ultimate population of the United States reaches 200 million, one does not see how the country can raise the desired primary foods, domesticated animals, lumber, paper and fibers." [17]

Just how much improvement can be effected by raising the average of our stock no one can tell. Some years ago Fraser wrote that a dairy cow not producing yearly 4,000 pounds of milk containing 160 pounds of butter fat was kept at a loss, and then proceeded to divide our cattle into three groups on the basis of production:

UNCLE SAM'S THREE HERDS OF DAIRY CATTLE [18]

Group	Milk, Pounds Yearly	Butter Fat, Pounds Yearly	Annual Profit	Annual Loss
1st 7 million.....	3,654	134	....	$7.25
2nd 7 million....	5,000	198	$ 7.85	....
3rd 7 million	6,765	278	26.82	....

Taylor estimates that the average milk production per cow can be increased from our 4,100 to 4,500 average of to-day to the 6,000 pound average now secured in Holland, Switzerland, Denmark and the United Kingdom. The beef cattle should produce 130 pounds of edible meat per year instead of the 110 now secured. If the number of pigs per litter raised to maturity can be increased from the present number of 3.5 to 4 or 5 the gain will be obvious.

Per Capita Food Production

The chart in Figure 11 shows that the per acre yield of the chief grains is much higher in Europe than in America. The actual figures for wheat are Germany 31.7 bushels, United Kingdom 32.4, Belgium 37, Canada 19, United States 14. The low figures of Canada and the United States must be considered in light of the fact that in the European lands 278 per cent more labor is employed per unit of land. "In these countries the extra expenditure is proportionately greater than the increase of yield so that the yield per unit of labor is much smaller than in the United States." [20]

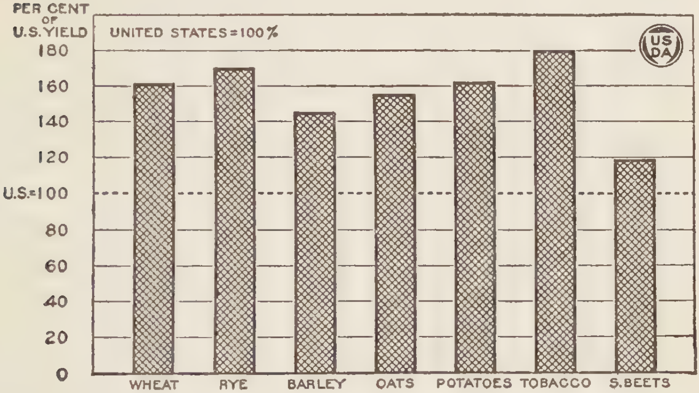

FIG. 11. AVERAGE YIELDS PER ACRE, 1909-1913, OF SEVEN IMPORTANT CROPS IN FOUR EUROPEAN COUNTRIES EXPRESSED IN PERCENTAGE OF AVERAGE YIELDS IN THE UNITED STATES [19]

The following table[21] shows the contrast both in the degree to which domestic animals are used and in the product per worker:

INDEX NUMBERS OF PRODUCTIVITY PER WORKER

Country	Number of Animals per Worker	Index of Volume Production per Worker
Italy	.19	45
France	.37	90
Belgium	.38	117
Germany	.55	119
United Kingdom	.88	126
United States	2.05	292
Alabama	.81	112
Indiana	2.41	365
Nebraska	4.71	910

This table indicates not only the per capita superiority in the United States but also shows the contrast in different states where the staple crops vary. In this country, work animals, almost wholly horses and mules, cost about twenty-five cents per hour for work done. In no other part of the world is so much machinery used. Our large per capita production is due to the happy combination of good land, and the employment of much capital invested in work animals and machinery. The writer in the *Yearbook* estimates a possible per acre increase in production in 46 per cent for our main crops, adding the significant comment, "when economic conditions shall justify the requisite cost of production." The actual increase for the last half century has been about 26 per cent.

There are, and always will be, both competent and incompetent farmers. As agriculture becomes a manufacturing rather than an extractive industry, as soils are better understood, and farmers better trained, an improvement in production is certain. There is, however, no probability that the average yield under all conditions can ever equal the average yield under the best conditions and with the most intelligent management. It was a happy coincidence that the age of machinery and the exploitation of some of the best farming regions on earth came together. Here laborers have been scarce. In the older lands man power has remained man power but in the new world it has been magnified into horse power—both of animals and machinery. Lescohier sums it up well:

> Thus far, agricultural production has held its own with population. Never in the world's history did man have so much to eat, so easily and cheaply obtained. R. N. New says that for two or three decades before the War, the fundamental economic fact was the cheapness of the main necessaries of life, and the steadiness in the world's markets year after year, of the price of the chief articles of food. Agriculture during the nineteenth century set for the world an abundant table at low prices. . . .
>
> Malthus was not wrong. The nineteenth century was an exceptional epoch in the world's history. Vast areas of cheap and fertile land, easily reached and comparatively easy to cultivate, were put under the plow. The new areas which will be brought into use during the twentieth century will require much larger investment of capital and labor to make them tillable, and will, on the average, be of lower fertility. Consequently, though the world is at present much more concerned about adequate markets for its farm products than about possible food shortages, the fundamental situation of all history is unchanged.[22]

Food Exports and Imports

Students know that the United States is ceasing to be a food-exporting nation and that it is importing increasing quantities of food. We exported 17 per cent of our meat during the decade 1896 to 1905 and only 12 per cent from

IMPORTS AND EXPORTS OF FOODSTUFFS

To and from the United States	Percentage of Total Value	
	1880-1899	1900-1919
Foodstuffs imported	16.92	12.51
Foodstuffs exported	21.80	14.09

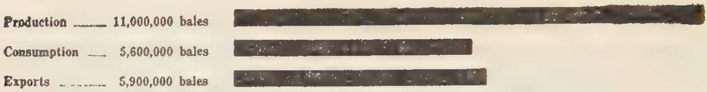

FIG. 12. YEARLY AVERAGES OF COTTON PRODUCTION, CONSUMPTION, AND EXPORTS IN THE UNITED STATES, 1920-1924

1916 to 1920. From 1880 to 1890 we exported 31 per cent of our wheat as compared to 23 per cent from 1900 to 1919. Our millers are even importing some high-grade wheat from Canada. The importation of edible vegetable oils was two and one-half times greater in 1920 than in 1912.[23]

The one agricultural product which we continue to export in great quantity, and shall continue to export unless the world gets a cheaper supply, is cotton. In as much as we produce about two-thirds of the world's supply and use less than half of our crop, foreign markets are necessary.

Forest Resources

In this country our favorable agricultural situation, the excessive amount of land in farms as compared to total needs,

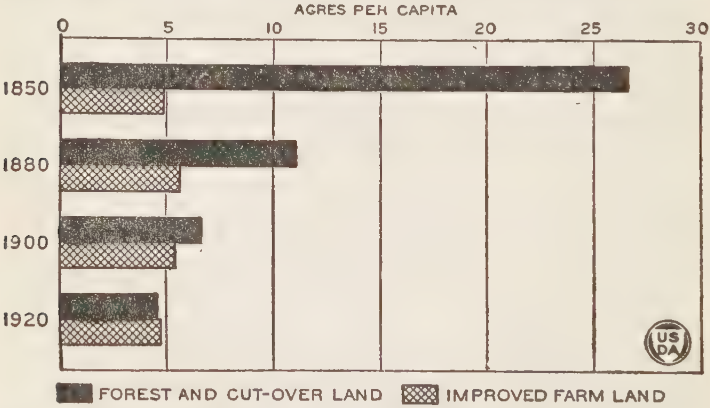

FIG. 13. PER CAPITA ACREAGE OF FOREST LAND CONTRASTED WITH THAT OF IMPROVED FARM LAND IN THE UNITED STATES, 1850-1920

have often caused trouble to the farmers by producing low prices, as during the last few years. These facts have blinded us to the growing pressure of population in so far as foodstuffs is concerned. It is obvious, however, in our forest and lumber situations. We have but to contrast the timber now standing with that found here by the early settlers. The timber land of the East originally covered 681,000,000 acres of which but 60,700,000 acres are left. The western forest covered 140,800,000 acres of which 77,400,000 acres are left.

Figure 13 [24] gives a comparison of forest and improved farm land at different periods. Figure 14 [25] shows the way in which we are destroying our forests to-day.

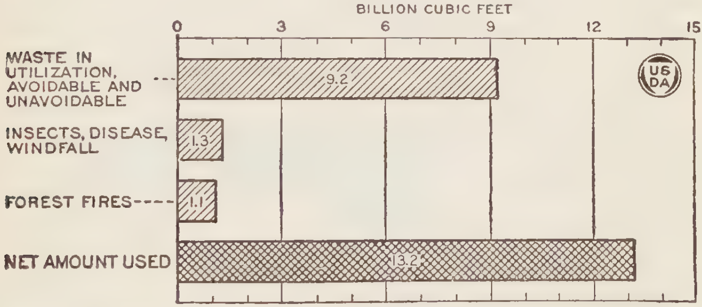

FIG. 14. AVERAGE ANNUAL REMOVAL OF STANDING TIMBER IN THE UNITED STATES THROUGH WASTE, DESTRUCTION, OR USE

The greatest volume of waste is in manufacturing use, comprising more than one-third of the timber annually removed. However most of this waste is not now avoidable without increasing considerably the cost of utilization.

Large amounts of such products as fuel wood, mine timbers, pulpwood, and fence posts come from small trees that are potential saw timber, and often indeed from trees of saw-log size. Yet, much of these materials could come from the immense quantities of wood now wasted in the form of tops, limbs, stumps, and small or crooked logs, and of small trees that, with benefit to the remaining forest, could be taken out as thinnings. Thus, Sweden has built up a large paper industry, which derives its raw material almost solely from classes of wood which we now waste in woods and factory. The salvaging of this waste would release immense quantities of young growth for ultimate use as saw timber. The annual loss to standing timber from fire, windfall, insects, and disease is estimated at 7¼ billion board feet, most of which could be avoided by proper protective measures.[26]

Every one knows how the price of lumber has increased by leaps and bounds. Down to 1880, Pennsylvania was a lumber-exporting state. Now it, and all the other northeastern states, are importing lumber from the South and West. Hemlock, disdained by early settlers, has replaced white pine. Even on the Pacific coast redwood has become a luxury product. To see how we use our lumber we have but to look at the following diagram.

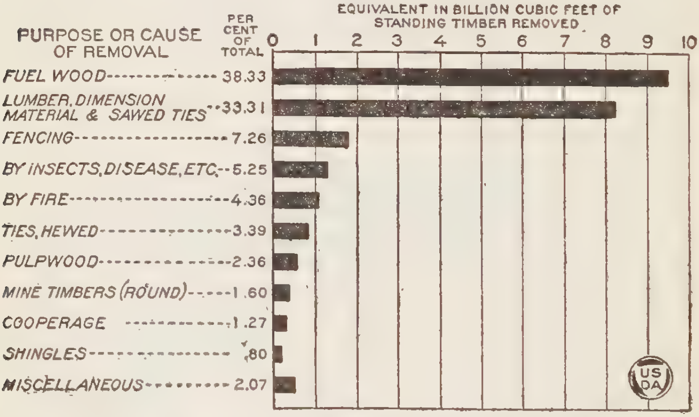

FIG. 15. AVERAGE ANNUAL REMOVAL OF STANDING TIMBER FROM THE FORESTS OF THE UNITED STATES ASSIGNED TO VARIOUS TYPES OF USE OR CAUSES OF DESTRUCTION

"Lumber, dimension material, and sawed ties comprise about one-third of the total, but the timber of saw-timber size removed for various purposes amounts to more than one-half of the timber annually removed. About two-fifths of the total is employed for fuel. Pulp wood, though economically of great importance, represents only a little over two per cent of the timber annually removed." [27]

Our present annual consumption of forest products equals 24,785,000,000 cubic feet or 234 cubic feet per capita which may be compared with the 27 cubic feet used in France and Germany and the 15 cubic feet of the United Kingdom. Fire, insects, disease, etc., destroy about 2,380,000,000 cubic feet in addition.

Forest Destruction

Not only have we used our timber recklessly, often destroying valuable timber to convert the land into agriculture areas for which it was not adapted, but our methods have been so wasteful that we have left some 80,000,000 acres cut-over land valueless either for lumber or agriculture. Moreover, we are destroying millions of acres yearly by fires often started by careless men, burning them at a rate 25 per cent greater than the new growth, according to a forest ranger writing in the *Outlook,* August, 1927. In 1926 there were 91,793 forest fires of which 72 per cent were caused by man. They burned 24,300,000 acres, causing a direct loss estimated at $26,900,000. The settlement of the Pacific coast, our last great forest reserve, where the summers are very dry, the increased mobility brought about by automobiles and the consequent entrance into forest areas of plain and city dwellers who little realize the fire hazard, are producing staggering losses. Further we have to reckon with the deliberate and malicious burning caused by disgruntled persons, or by migrants from eastern forest lands who have a tradition of land clearing by fire, as well as the danger of accidental ignition by railroad locomotives, and the ever present danger through lightning. Already we are importing much fine lumber. We are building flimsy structures, skimping the material as well as lowering its quality. America is not the only place where man has destroyed the forests. China is a classic example. Even in Europe there are areas on the Mediterranean as well as on the Baltic, once forested but now almost useless.

Meantime the development of new industries has added to the demand. The enormous expansion of the use of paper, the use of wood pulp in the manufacture of "artificial silk" has driven us to the importation of raw materials. Whence are to come the telephone poles and railroad ties in the future? Who can measure in terms of money the cost a century hence? The Lord only can make a tree, and he takes plenty of time. This is not the place to discuss the problems of forestry. How much forest land we may need is a matter for experts to consider. France keeps nearly one-fourth of her area in forests and still has to import lumber. That which is here sought is to make vivid the pressure of increasing population on resources.

Plant Breeding

Some students, like J. Russell Smith, recognizing the facts, are quite optimistic about the future, and emphasize the development of new foods, better varieties of plants, etc. In his book, *North America,* he cites many improvements such as the increase in the use of soy beans in Iowa in recent years, thus producing larger amounts of stock feed. He mentions the increase of the oil content in corn from 4.7 to 7 per cent through breeding experiments in Illinois; the increase of the protein content from 6.65 to 16 per cent. The introduction of the drought-resisting and early ripening durum wheat, producing an increased yield of 50 per cent. The production of the Marquis wheat by the deliberate crossing of the Fife and an Indian wheat in 1892 until by 1918 it comprised 90 per cent of the wheat grown in western Canada. He stresses the production of navel oranges; of hybrid chestnuts to resist the blight. He calls attention to the fact that most varieties of cultivated plants are of recent origin. He advocates the use of nuts as food, thus producing valuable lumber and food on the same ground.[28] His critics gladly welcome all possible improvement in plants but are skeptical as to the extent of the possible increase.

As East says:

> After all is said and done, then, what Doctor Smith is really recommending is a more varied diet, and this is a recommendation suitable for a new territory of increasing agricultural returns and a relatively small population, not for a country or a world saturated with people. When the arable land is all taken up and is being cultivated as intensively as possible by workers who need to make every square foot yield its best in order to keep the wolf from the door, it is no particular relief to him to tell him he might grow mangoes or taros or something else he never heard of, unless these plants will give him a better return than what he is then raising. In other words, one crop at a time and full use of the growing season is all that can be done. If land is growing maize it cannot grow wheat or potatoes. If I may venture a prediction, I should be inclined to say that increasing population pressure will bring about the use of fewer crops rather than the reverse. The easiest way will be to produce high-yielding varieties adapted for different conditions of soil and climate within a very limited number of species. We shall cover our land with the best crops compatible with strict dietary necessities, and there we shall stop.[29]

East thinks that an increase of from 10 to 20 per cent is all we can hope from plant breeding. Smith and other have stressed the greater use of fish and other sea foods. What the future may show as to possibilities no one knows. Up to the present it appears that man has depleted the ocean to some extent and larger supplies are not now in sight.

Metal Supplies

Little need be added on the question of metal supplies to the discussion in an earlier chapter. Technical advance has kept their price relatively low but as mining difficulties increase the cost of production must increase. In our anthracite fields the point of diminishing returns has been passed. Of fertilizers our greatest shortage is in potash. This we can secure from lower grade ores at increasing fuel costs. "Moreover our dependence on the mineral fuels becomes every year more nearly complete. Prior to 1850 they furnished less energy than even the work animals. As late as 1880 the minerals were subordinate to firewood. In 1890 they contributed 60 per cent of the supply. In 1923, as just stated, their contribution was 87 per cent of the total energy supply." Brick or iron instead of timber for building requires more fuel used in their manufacture. "The energy in an entire year's production of human foods in the United States is equal to only 3 per cent of that in our annual output of fuels." Raw materials demand much fuel. "We now consume over 200 million tons of fuel, equal to a third of our total output of coal, simply in mining, and in smelting and transporting the products of the mines." [30]

Indefinite Increase of Population Impossible

It must be that those who talk glibly of the additional hundreds of millions of men who are to live in America have never taken the time to inquire into the matter. No one can predict what improvements may come through new discoveries and inventions but those who are interested in maintaining high standards of living should begin to consider the warnings issued by men of high standing. The indefinite increase of human beings is bringing serious consequences, both within the separate countries and in international relations. This is not the place for the discussion of the social problems involved but he must be blind who does not see that the subject matter of this chapter has very definite relationship to current political questions.

Conditions in America are changing rapidly. A few scattered items may show the direction of the wind. Up to 1900 the increase in cultivated land was greater than the increase in population; 32 per cent against 25 per cent from 1880-1890; 29 per cent against 24 per cent from 1890-1900. The next decade shows a change. Cultivated land increased 10 per cent while the population increased 21 per cent. From 1900-1910 the price of farm land double. Food prices increase. The amount of stock declines. In 1923 the population was four times greater than in 1850 but the number of live stock had not doubled; 134 hogs in 1850 to every one hundred persons; 58 in 1923. We have had as high as 60,000,000 sheep, now we have only 40,000,000. Of cattle, sheep and swine we had for every human being in 1880, 2.15; in 1920 only 1.77. The housekeeper knows what is happening to the price of meat. Will we be forced to a mere existence level?

This last is the possibility of which Malthus was afraid. "All unwholesome occupations, severe labor and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common disease and epidemics, wars, plague and famine" were to him the "positive checks" to population. But to men is reserved the possibility of a "preventive check"—the voluntary restriction of population for the sake of maintaining high standards.

The tremendous advances of the nineteenth century caused Malthus to be ridiculed by the casual observer who wanted to know when the Malthusian Law was to begin operations. One might as well ask if the law of gravity is suspended when the airplane rises. With the advent of the twentieth century the phenomena discussed by Malthus received greater consideration and there has developed a movement for birth control which has gained headway in the face of great opposition. The merits of the suggestion do not now concern us. We may pass over also the very important studies of Pearl as to the nature and rate of population growth.

The Birth Rate

Is it true, as the writer of Ecclesiastes said, "When goods increased, they are increased that eat them"? Is this recent rapid increase of many races of men a passing phenomenon, a response to suddenly enlarged opportunities? If so, may we expect a decline as conditions change? It is not easy to find answers to such questions. Long ago it was noted that the older American stock was not reproducing as rapidly as in earlier years. Willcox, a trained observer, believes that the decline in the birth rate began as early as 1810 in the United States. General Walker asserted that immigration produced no net addition to our population, assuming that the older birth rate would have continued had there been no immigration. Recently Baber and Ross in Wisconsin have found a shrinkage in the number of children from 5.4 per family to 3.3 in a single generation. In 1920 the foreign born and their native-born children constituted 34.4 per cent of the population.

Dublin[31] has claimed that of every thousand females in this country only 788 will marry. If so each thousand married women must bear 1,268 daughters to replace the sex. Each thousand married men must have 1,350 sons to maintain the number of men. Thus each thousand families must have 2,618 children (2.6 per family) to replace the original number. But, at present, one marriage out of six is childless, hence, the remaining five must have 3.1 children each. Dublin believes that the evidence shows that we are just about maintaining a stationary population.

Just now, Dublin thinks, the number of people in the reproductive years is abnormally high, owing to immigration and to the recent advance in the medical arts. If we allow for this and adjust to normal age distribution the present birth is not 23.4 as generally stated, but 20.9. The death rate is not 12.4 but 15.3. If so, the present rate of natural increase is not 11 per thousand but 5.5. If we had to-day the mortality rate of 1910 the increase would be only 3.6 per thousand, while if the rate of 1901 obtained there would be no increase. Dublin, therefore, sees no reason to fear any rapid increase. The stoppage of immigration will soon enable us to get much more reliable information.

After all it makes little difference whether the rate of increase be as slow as Dublin thinks or as rapid as Pearl believes. The important thing is that all students admit the increase and admit that in great areas of earth the standard of living is very low, not because people prefer low standards but because they cannot maintain higher. Pearl has taken a sound attitude.

> *Is There a Solution?*
>
> I am able to make no prediction as to how civilized countries will solve (if they do solve) the problems arising out of the impending saturation with human population of the portion of the earth's surface habitable by man. The certainty and assurance with which various ones of my friends advance solutions excites my wonder and admiration. But what impresses me even more is that scarcely any two of them agree on the nature of the panacea. To some it is birth control, to others it is synthetic foods derived from the atmosphere or elsewhere, and so on.
>
> For myself, I am content if I have succeeded, in even a small measure, in indicating that population growth presents a problem fast becoming urgent; a problem that in its overwhelming significance and almost infinite ramifications touches upon virtually every present human activity and interest, and in particular upon the activities comprised in the terms public health and hygiene.[32]

The writer freely confesses that he likes to get away from fellow man once in a while and commune with nature. He finds this increasingly difficult and at times yearns for more nature and fewer men. Is such an ideal wholly unworthy as compared with that which leads to a land as crowded with humans as China or India? Do we want to *live* or just exist?

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29. E. M. East, *op. cit.,* pp. 164-165.
30. Tryon and Mann, in *Population Problems,* pp. 120-136.
31. L. I. Dublin, *Population Problems,* pp. 10*ff.*
32. R. Pearl, *The Biology of Death,* p. 258.

PART III

MAN TRIES TO UNDERSTAND

CHAPTER X

THE ASCENT OF MAN

A fire mist and a planet,
A crystal and a cell,
A jellyfish and a saurian,
And caves where cavemen dwell—
Then a sense of law and beauty,
And a face turned from the clod;
Some call it Evolution,
And some call it God.
—W. H. GARRUTH

THE INFINITE VARIETY OF LIVING THINGS

The untrained eye, easily misled by superficial resemblances, fails to note the trifling differences which distinguish one form of life from another. Everyday experience proves the truth of this statement. John Doe claims that he has been bitten by the house fly. The student asserts that the culprit was a stable fly which John Doe confuses with the former. The average reader will be astonished at the results if he will but check himself as to his knowledge of details of life about him. This difficulty is increased by the necessity of describing new forms in old terms. The Roman soldier who described the elephants of Hannibal as "enormous oxen with tails at both ends" stands side by side with the Indians who thought that the boats of the Europeans must have been hollowed from the trunks of enormous trees. So too the Europeans coming to America fastened old names on local animals. The animals we call rabbits are, in reality, hares. It took man long centuries to get away from careless descriptions to accurate names of fixed value and even to-day common names the world over are confused and confusing. Even the binomial classification of Linnæus did not wholly meet the problem when man became able to distinguish varieties as well as species. That the shepherd knew his sheep and could call them by name was known of old. Man has always developed the keenest vision in dealing with things of everyday importance to himself. Yet how many of us can tell toadstools from mushrooms? Outside of a narrow field man's information has always been shaky and often incorrect. Only by a very slow process of accumulation has he achieved wide knowledge of things on earth—and many gaps still exist.

Man Asks Why?

As if the difficulty of listing the various forms of organic life were not great enough in itself man creates another. He is like the small child with its eternal "Why?" That is, man wants explanation of what he sees, and begins the development of speculation and theory. Both are excellent and unavoidable but they bring a new danger. Man now sees things in the light of a theory and tends, unconsciously, to make his facts conform. This is peculiarly true when the theories have become fixed beliefs, traced to some authority which is not open to question.

Theology versus Science

It so happens that most of the development of natural science has taken place in countries whose inhabitants have long held a belief that the early chapters of the Bible gave an accurate account of the origin of living beings and their relations to one another. Hence it has happened that any evidence from the book written in the rocks or in the habits of animals, a record written by God if ever one was, has been opposed as antagonistic to religion if it could not be made to agree with the Biblical account. Neither church nor state has been logical or consistent in the upholding of this position but they have stressed it often enough to make it a real factor in our development. The merits of the question do not now concern us but a couple of illustrations may be given.

For long ages the earth was held to be the center of the universe. When Galileo among others began to make the sun the center, the authorities of the Roman Church were disturbed and thus expressed their disapproval:

> The proposition that the sun is the center of the world and immovable from its place is absurd, philosophically false, and formally heretical, because it is expressly contrary to the Holy Scripture.
>
> The proposition that the earth is not the center of the world, nor immovable, but that it moves, and also with a diurnal motion, is also absurd, philosophically false, and, theoretically considered, at least erroneous in faith.[1]

The story of Noah's ark caused no difficulty until the Europeans began to travel about the earth and to find many species of animals both new and strange. How would so many have found refuge in one boat? As a solution to this problem Origen suggested that the cubit was six times longer than had been supposed while Bede claimed that Noah had spent one hundred years in its construction and that the animals on board had been miraculously fed. Even the *Encyclopædia Brittanica* in the first edition (1771) asserted:

> The number of species of animals will be found less than is generally imagined, not amounting to a hundred species of quadrupeds, nor to two hundreds of birds: out of which in this case are excepted such animals as can live in the water. Zoölogists usually reckon but one hundred and seventy species in all: and Bishop Williams shows that only seventy-two of the quadruped kind needed a place in the ark. . . . It is agreed that the lower story was for beasts, the middle for food, and the upper for the birds with Noah and his family, each story being subdivided into different apartments, stalls.[2] . . . .

Marco Polo claimed to have seen the ark resting on Mount Ararat on one of his voyages but he appears to have failed to measure it. To-day we know that there are thousands of species.

Species

What, then, is a species? To the men of the Middle Ages this was a simple question. The Lord at the time of creation had made at least two (more according to some authorities) of each sort of animal and that these had reproduced throughout the ages and that new forms had not reappeared. This idea was held in early life even by such men as Linnæus, Lamarck and Darwin. The answer to-day is far less simple. Through the window I see a bunch of little bantams frisking about a bevy of sedate White Rocks. If the naturalist found these two forms in a new country he would unhesitatingly label them as two species. It happens that we know that they and all the other races of chickens are to be traced back to the jungle fowl of India. Shall we call these various races of chickens "species" or "varieties"? Much more is involved than a mere choice of terms.

Hybrids

According to the older belief, species could not cross and produce fertile offspring. In some cases this seems to be true as in the cross of the horse and the ass or of the two camels. Even here we do not know that fertile offspring never result nor do we know why the half-breeds are not fertile. The crosses of the European cattle and the American bison are fertile. Fertile crosses of ducks and geese are known. Crossbred plants are very numerous. To-day we do not know where the limits are which nature may have established. We have to speak of varieties as well as species.

Varieties

In reality species often shade into each other by almost imperceptible degrees. When I was a boy all the bird lists gave two species of American hawks as distinct species, the common red-tailed hawk and the rare Harlan's hawk. When the collection of skins at the National Museum became large enough it was seen that one shaded into the other and Harlan's hawk was relegated to the position of a color variety of the common form. The heath hen of Nantucket was long identified with the prairie chicken of the West. The golden-winged woodpecker of the East and the red-shafted flicker of the West are distinct enough but the intermediate forms are endless.

As knowledge has increased the number of varieties has grown. Whereas the older students based their classifications largely on external characters, now every detail of anatomy is compared and many shifts even from one genius to another have been necessary. The results are often surprising. The whale is nearer to the pig than any fish. The eel is a fish and not a water snake. The meaning of all this is that the extent of the relationship between various forms of life is greater than was once thought. Stated in another way, the known facts no longer fit the old theory and some new interpretations must be sought. Again we see that nature cares nothing for the hard and fast lines of distinction which man has sought to establish.

Fossils

Even in primitive times man must have found fossil remains. When he began to notice them and seek for an explanation we shall never know. In Europe during the Middle Ages fossils were known and variously interpreted. Sometimes large fossils were exhibited in churches as proof of the Biblical statement that "there were giants in those days."

Zenophanes (500 B.C.), as well as Leonardo da Vinci two thousand years later, caught the true explanation but popular opinion was not satisfied. They were caused by some "formative quality" or "plastic virtue" of the soil; by some "lapidific juice," or the influence of heavenly bodies. Perhaps the devil had made them in order to upset man's faith or perchance God had made them to test man's faith. As collections were made the true interpretation became unavoidable, but this raised some great difficulties especially after man knew enough to measure the relative age of the rocks in which they were formed.

It became apparent that the animals whose bones formed the fossils were very different from animals known to be alive on earth. Moreover, existing forms were not found in the fossil-bearing strata. Evidently these old types had once lived in large numbers and it was not easy to imagine what had destroyed them.

The French naturalist Baron Cuvier (1769-1832), the founder of vertebrate paleontology, seems to have been the first to gain a wide knowledge of fossil forms. He sought to explain their appearance and disappearance by assuming a series of special creations, followed by a series of cataclysms or catastrophes which destroyed them, their places being taken by immigrant forms coming from some creation center. That the fossil forms might in any way be ancestral to the latter seems not to have occurred to him. Such catastrophes may well have played a part in the local destruction of many organisms. It is hard, for instance, to imagine the survival by horses and cattle of the 1927 flood of the Mississippi River, unless they were aided by man. Nevertheless the increasing body of facts did not fit the theory of Cuvier and, after many revisions, it was abandoned. To this the growth of the idea that we can best explain the past by the present may have contributed. We find plenty of gradual changes, few catastrophes, and no sudden appearances of markedly new forms of life. Serial creation would have to be endless to meet possible future catastrophes.

As geology developed it was discovered that there was an order in the appearance of the fossils. Now we divide the history of the rocks into ages and we find that fossils are characteristic of each as is shown in the table on page 25ff. The record begins with the lowest shell-forming types and goes on to the age of mammals. Again hard and fast lines are impossible. Birds and reptiles have certain similarities of structure which are striking. The early mammals are not like the later but there seem to be certain resemblances and the change appears to be a step at a time rather than cataclysms, though the scene shifts from one part of earth to another, for the whole story is not told in any one area.

Geographical Distribution of Life

The current distribution of life on earth had long puzzled thinking men. Since the earth was held to be a plane, evidently no animals could live on the lower side, for either they must fall off or else stand with feet above their heads. St. Paul had declared that the Gospel had gone to all lands, hence Augustine concluded that there could be no persons living in the Antipodes or other unknown and distant areas. He thought, too, that God had caused, or permitted, the angels to distribute the animals over the earth. In 1667 Milius was puzzled by the fact that many animals common on earth were not found near Mount Ararat. He could not conceive of their having wandered so far. The suggestion that they had been carried by human agency was opposed as early as 1590 by Joseph Acosta in his *Natural and Moral History of the Indies*. "It was sufficient, yea, very much, for men driven against their willes by tempest, in so long and unknowne a voyage, to escape with their owne lives, without busying themselves to carrie woolves and foxes, and to nourish them at sea." [3] Even assuming that good travelers had made their way over earth, how could such species as the sloths of South America make so great a journey from Mount Ararat? If the kangaroo, duckbill and apteryx could reach Australia, why not the carnivorous wolves and tigers of Asia?

Variation

The variation of domestic plants and animals must have been observed in early times. This seems to have caused no special concern, for even the church fathers could hold to spontaneous generation and satisfy their minds in some such fashion as did Aquinas when he wrote: "Nothing was made by God, after the six days of creation, absolutely new, but it was in some sense included in the work of the six days" and that "even new species, if any appear, have existed before in certain native properties, just as animals are produced from putrefaction."[4] The fundamentalists of to-day might do worse than ponder the possibilities of the argument of Aquinas.

Omitting from the present discussion the brilliant speculations of the Greeks, unhampered by Biblical questions, a thousand years elapse from the time when Augustine gave his mighty approval to the authority of the Bible and the raising of a question as to the immutability of species by Francis Bacon (1561-1626). Bacon asked if the changes which had taken place might not be explained as the accumulated effects of variations. From this time on an increasing group of men, including both scientists and philosophers, Leibnitz, Schelling, Kant, Goethe, Lessing, Descartes, among them, are questioning the older explanation.

THE EXPLORERS OF EVOLUTION

Linnæus

In the seventeenth century John Ray had started to catalogue plants and animals but the new era in natural science really dates from the work of the Swedish botanist Linnæus (1707-1778). At first he held to the common opinion of his day but as his information grew he was forced to modify his ideas. By 1762 he admits, following the suggestion of the Benedictine Dom Calmet, that "all the species of one genus constituted at first one species; they were subsequently modified by hybrid generation: that is by intercrossing with other species."[5] In the last edition of his great work, *Systema Natura,* he no longer asserted the fixity of species.

Buffon

The French student of animal life, Buffon (1707-1788), was the next naturalist to break from the old views. "The pig does not appear to have been formed upon an original, special and perfect plan, since it is a compound of other animals; it has evidently useless parts, or rather parts of which it cannot make any use, toes all the bones of which are perfectly formed, and which nevertheless, are of no service to it. Nature is far from subjecting herself to final causes in the formation of her creatures."[6]

In middle life he emphasized the rapid variation of species. "One is surprised at the rapidity with which species vary, and the facility with which they lose their primitive characteristics in assuming new forms." Or again: "How many species being perfected or degenerated by the great changes in land and sea, by the favors or disfavors of nature, by food, by the prolonged influences of climate, contrary or favorable, *are no longer what they formerly were.*"[7]

Buffon saw the changes in domestic animals. He noted the high birth rate, the struggle for existence, and the elimination of many individuals. He hints at the common origin of the ass and horse, of man and ape. He thought that the environment modified animals and urged that present changes be studied in order that older changes might be understood. It is hard to judge Buffon. Frequently he is contradictory. When attacked on theological grounds by the Sorbonne he recants. When expressing himself on some moot points he suggests that his view cannot be true in as much as the Bible teaches the contrary. He had less immediate influence than Linnæus, largely because he was ahead of his time, but he greatly stimulated research, and was later hailed by Darwin as a great predecessor.

Erasmus Darwin

Erasmus Darwin (1731-1802) squarely broke away from the idea of special creation. He thought that life originated in water:

> Hence without parents, by spontaneous birth,
> Rise the first specks of animated earth.

In unmistakable language he pictures the evolution of life from its simplest forms to man himself:

> When we revolve in our minds the metamorphosis of animals, as from the tadpole to the frog; secondly, the changes produced by artificial cultivation, as in the breeds of horses, dogs and sheep; thirdly, the changes produced by conditions of climate and season, as in the sheep of warm climates being covered with hair instead of wool, and the hares and partridges of northern climates becoming white in winter; when, further, we observe the changes of structure produced by habit, as seen especially by men of different occupations; or the changes produced by artificial mutilation and prenatal influences, as in the crossing of species and production of monsters; fourth, when we observe the essential unity of plan in all warm-blooded animals, we are led to conclude that they have been alike produced from a similar living filament.[8] . . . Many features in the anatomy of man point to a former quadrupedal position, and indicate that he is not yet fully adapted to the erect position; that, further, man may have arisen from a single family of monkeys, in which, accidentally, the opposing muscle brought the thumb against the tip of the fingers, and that the muscle gradually increased in size by use in successive generations.[9]

The theory of natural selection is almost the sole thing in which Erasmus Darwin failed to anticipate his more famous grandson.

Lamarck

Though there is no evidence that Lamarck (1744-1829) knew of the work of Erasmus Darwin there is a striking similarity in the ideas of the two. Lamarck, a botanist in early life, shifted into zoölogy and was placed in charge of the invertebrates at the Jardin des Plantes in Paris where he found Buffon and Cuvier among his associates. Up to this time he believed in the fixity of species. In 1802 he suggested the use of the word *biology* and sketched a theory of evolution. His *Philosophie zoölogique* (1809) presents his ideas in complete form. His general concept is simple. The creator endowed matter and life with their qualities. The lowest forms appeared first and probably continue to appear. Thereafter there is a slow, continuous evolution which has taken enormous periods of time. The environment directly operates on plants to modify them but on animals the influence is indirect ordinarily. That is, the environment causes changes in the needs and habits of organisms, and changed habits cause new developments in the body of the animal. His fourth law states: "Everything which has been acquired, or changed in the individual during its life is preserved in the process of reproduction and is transmitted to the new individuals which come from those which have undergone the changes." This is the basis of his famous "use and disuse" theory or the "inheritance of acquired characters" so generally associated with his name, which will receive consideration later.

Poor, and blind in his later years, Lamarck was opposed and ridiculed by the mighty Cuvier and he made little impression even in France. Lamarck could understand the disappearance of the lower forms through sudden environmental changes but held that man must have destroyed such great forms as the mammoth. It was not until the middle of the last century that Lamarck was recognized as one of the great men of his day.

The first quarter of the nineteenth century brought little advance in this field. Patrick Matthew in 1831 was the first to state clearly the idea of natural selection. The anonymous work, *Vestiges of the Natural History of Creation* (1844), generally attributed to Robert Chambers, was written from an evolutionary standpoint and excited much comment. Meantime the botanists were approaching the new viewpoint. Meckel and von Baer showed how similar all animals were in the embryonic life. The stage was being set for the entrance of a group of men destined to have such an influence on human thought that even to-day one hardly dares attempt to measure it. The two men most responsible for the movement were Charles Darwin (1809-1882) and Alfred Russel Wallace (1823-1913).

Charles Darwin

In his *Naturalist's Voyage Round the World* Darwin wrote:

> In October 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of plants and animals, it at once struck me that under these circumstances favorable variations would tend to be perserved and unfavorable ones destroyed. The result of this would be the formation of new species.

At this time Darwin believed that species were separately created. Four years later he admits that he is "almost convinced that species are not (it is like confessing a murder) immutable." He began to write in 1842, showing his work to the geologist Lyell and to Hooker. Though urged to he held back until he received in 1848 a paper from Wallace in which he found his own ideas independently worked out. It later appeared that Wallace had also been inspired by Malthus. Wallace asked Darwin to forward his paper to Lyell if it was thought worthy. Darwin would have yielded place to Wallace but friends objected and the upshot was that Wallace's paper, together with an abstract of Darwin's under the title "On the Tendency of Species to Form Varieties and on the Perpetuation of Varieties and Species by Natural Selection," were read at a meeting of the Linnæan Society, July 1, 1858. The following year Darwin published *The Origin of Species.* In this volume there are only vague references as to the connection of man to other organisms, although the inferences are clear and Darwin's work on *The Descent of Man* was not issued until 1871. Darwin continued his careful, patient study of nature throughout his life. I would strongly recommend that any person who desires to get an idea of the character of Darwin's work should read first such an essay as *The Formation of Vegetable Mould through the Action of Worms* (1881), rather than one of the earlier works.

The Idea of Evolution

In estimating the works of Darwin we must be careful not to confuse two distinct things, (1) the evidence he offered as to what had taken place, and (2) the theories he offered to explain what he had seen. Darwin himself once said that mistaken theories are stimulating but that mistaken observations are sterilizing.

On the first point there is no dispute. Darwin was one of the most competent, and modest, students the world has produced. So compelling was the evidence he offered that outstanding natural scientists like Asa Gray and John Fiske in America, Lyell and Huxley in England and Ernst Haeckel in Germany were immediate converts. A few older men like

Agassiz refused to be convinced, yet he, like Cuvier and Linnæus in earlier days, helped collect the evidence which compelled the acceptance of an idea of evolution. Huxley and Haeckel became the great champions of the newer interpretation against its philosophical antagonists. Herbert Spencer, already an evolutionist, joyfully welcomed the new evidence, and in his *Synthetic Philosophy* was the first to make universal application of the new principle. In a few years the battle was over so far as the scientific world was concerned, and for half a century every man of any repute as a scientist has been an evolutionist. This contest had its amusing as well as tragic features and among the former may be listed the refusal of Whewell, author of a great *History of the Inductive Sciences,* to allow a copy of *The Origin of Species* to be put in the library of Trinity College, Cambridge.

DARWINISM

In scientific circles Darwinism refers to the theories of Darwin, not to the question of evolution. There is much confusion on this point in the general public. As Kellogg says:

> To too many readers Darwinism is synonymous with organic evolution or the theory of descent. The word is not to be so used or considered. Darwinism, primarily, is a most ingenious, most plausible, and, according to one's belief, most effective or most inadequate, causomechanical explanation of adaptation and species-transforming. . . . The fact is that the name Darwinism has been pretty consistently applied by biologists only to those theories practically original with Darwin which offer a mechanical explanation of the accepted fact of descent. Of these Darwinism theories the primary and all important one is that of natural selection. Included with this in Darwinism are the now nearly wholly discredited theories of sexual selection and of the pangenesis of gemmules. . . . The fair truth is that the Darwinian selection theories, considered with regard to their claimed capacity to be an independently sufficient mechanical explanation of descent, stand today seriously discredited in the

biological world. On the other hand it is also fair truth to say that no replacing hypothesis or theory of species-forming has been offered by the opponents of selection which has met with any general or even considerable acceptance by naturalists.[10]

Pangenesis

In judging the theories of Darwin it must be remembered that he started with the common notions of his day from which he could not escape and that his primary interest lay in the question of survival. Variation he saw all about him in the world. He believed that the development, or degeneration, of parts of the body were in some way influential in determining the characters of the next generation. He made a guess that from the affected part some messenger as it were, a bit of matter which he called a "gemmule," was sent to the reproductive organs to be incorporated in the germ cells from which the offspring were to come. When the study of cell life developed it was quickly learned that the germ cells are not formed in this fashion and the idea of pangenesis was discarded at once.

Sexual Selection

Darwin was familiar with the contests of the males over the possession of the females and the many intricate courtships of the animal world. He hazarded a guess that here was a sort of sexual selection, the females either belonging to the successful males or picking out those of greatest beauty or possessed of greatest dancing ability. This is an afterthought on Darwin's part and is in reality an interpretation of animal conduct in human terms. For all that we know the females cannot appreciate the beauty of the males or may consider their performances as silly and in bad taste. We know so little of the reasons for the choice of mates among humans that we must hesitate to explain animal conduct. Hence sexual selection has not won general acceptance.

Natural Selection

The theory of natural selection has been far more successful. It has been noted that this did not originate with Darwin solely. Darwin was very familiar with the rapid variation of domestic plants and animals. Here he saw that man by process of artificial selection determined what types should be preserved and what types prevented from reproducing. This suggested that in the natural world a similar process might take place, in as much as the high birth rate always assured an abundance of forms from which selection might be made. Darwin saw that any given type of life is neatly adjusted to the conditions under which it lives. Any variation therefore is likely to spell disaster. But conditions may change or there may be a shift to a new environment. Then the variant type may have an advantage and will survive while the old type dies out. Here we have what is called natural selection. This is a brilliant generalization supported by a multitude of cases for which, as Kellogg says, no other explanation has won acceptance. It does not account for variation but it does seek to explain survival. A few cases will serve as illustrations.

Protective Coloration

With silk threads Cesnola tethered forty-five green praying mantises to green herbage, and sixty-five of the brown variety to withered plants. He watched them for seventeen days and all survived unnoticed by birds. But when he put twenty-five green ones among brown herbage all were killed by birds in eleven days, while of forty-five brown ones on green grass, only ten survived at the end of seventeen days. Here we have definite proof of a selective death-rate, definite proof of the selective value of the protective coloration.[11] . . . .

Poulton and Saunders fastened 600 pupæ of the tortoise shell butterfly (Vanessa urticæ) to nettles, tree-trunks, fences, walls, and so on. At Oxford there was a mortality of 93 per cent, pointing to an extremely high elimination-rate, and the only

> pupæ that survived were *on nettles,* where they were least conspicuous. At St. Helena, in the Isle of Wight the elimination was 92 per cent on fences where the pupæ were conspicuous, as against 57 per cent among nettles where they were inconspicuous.[12]
>
> Dr. C. B. Davenport . . . placed 300 chickens in an open field. Eighty per cent were white or black and hence conspicuous; twenty per cent were spotted and hence inconspicuous. In a short time twenty-four were killed by crows but only one of the killed was spotted.[13]

There are other cases where the results are not in accord with those just given.

> The large tomato worm . . . occurs in two colors, being generally green, almost exactly matching the tomato leaves and stems on which it lives, and more rarely brown and very conspicuous. These caterpillars may be observed to be not infrequently eaten by robins and cuckoos and pecked to death and partially eaten by chipping sparrows. Last summer 34 of these caterpillars were counted on a row of tomato plants. Of these 32 were of the green and only 2 of the brown phase. . . . Later in the summer the number of these caterpillars was observed to be gradually diminishing until in early September, when they had attained their full growth, the green ones had been reduced to 18, while both of the brown ones remained. Furthermore, it became apparent that no less than 16 of the green caterpillars were parasitized by an ichneumon fly to whose attacks they eventually succumbed, with the net result that in spite of being protectively colored, out of 32 green caterpillars at the beginning of the season only two—a number just equalling that of the unprotected brown caterpillars—survived to pupate with the latter.[14]

Obviously protective coloration is not the only factor determining survival and in the case just cited may have had nothing to do with survival. Mimicry, the close resemblance of one variety to another, the moth which resembles a dry leaf when at rest, has been stressed by some students. Many physical characters seem to have no significance. No one suggests that the passenger pigeon was killed off because it had twelve feathers in its tail, while the very similar mourning dove survived because it had fourteen. On the other hand, the habit of the former in flying and nesting in enormous flocks as compared to the relatively solitary life of the latter may have been a factor. But can we account for this social life on physical grounds? There seems to be no selective elimination when the tornado kills all in its path save such as chance to be protected, nor in the killing by lightning of any person who chances to be in a particular place, nor in the destruction caused by the drying up of a stream. But, if perchance, some individuals survive the drought because of a greater resisting power there may be real selection. A little difference in the thickness of the skin might save cattle in a tick-infested region. While it is possible to exaggerate some feature which catches our eye, or to be mistaken, there seems to be such a thing as natural selection, and the explanation bids fair to last at least until some genius like Darwin comes along with a lot of new evidence which forces revision.

Evidences for Evolution

Regardless, then, of what happens to the Darwinian explanations, for this is unimportant, the naturalists believe in evolution more firmly than ever and much more evidence is at hand than Darwin could offer eighty years ago. This evidence comes from many fields.

Paleontology

The study of ancient life. With the possible exception of one Lingula (brachiopod) all living animals are different from the oldest fossils. Yet our minds can explain present forms only in terms of descent from the older. The entire history is not clear and may never be, and cannot be read in any one section of earth, but each decade increases our information. The pedigrees of the horse, camel and elephant are fairly complete. One of the first criticisms of the theory of evolution concerned the so-called "missing links" which should be forms intermediate between various types of life. True enough there are links missing and missing links also. The chance of survival of representatives of any type of life over vast ages is small enough, and the chance that they may be discovered in fossil form by a man informed enough to understand is perhaps even less. Nevertheless, connecting links are known, some of them among living animals. The Dinophilus lies between the flatworms and the annelids (such as earthworms). There are primitive centipedes connecting worms and centipedes. The lung fishes may live out of water and breathe air. The monotremes of Australia remind us of reptiles as well as birds. Attention was called earlier in the chapter to the difficulties of classification due to the presence of intermediate forms between the species. Even the oldest fossil remains of the human family differ widely from present skeletons.

In the history written in the rocks—a history not written by man, inspired or uninspired, but written in a language man can read—long ages pass ere warm-blooded mammals are found. As earlier noted, Asia appears to have been their distribution center. The primates first appear in the lower Eocene deposits both of Europe and North America. These rocks in Wyoming and New Mexico contain many remains. They disappear at the close of the Eocene, to reappear and survive in South America. The history of Europe is similar except that Europe is invaded by the Barbary ape of Africa in the Miocene which disappears at the close of the Pliocene save in Gibraltar where it still survives.

Morphology or Comparative Anatomy

The architect of organic life has used certain structural plans over and over. All fish have a similar structure in spite of wide specific differences. The same is true of mammals whether they walk on one toe like the horse, or flat-footed, like man. Common observation tells us that the greater the resemblance in details the closer the actual relationship. Identical twins are more nearly alike than ordinary brothers, cousins vary still more. The Yankee and the Eskimo are far apart yet it is evident that they are cast in the same pattern. From the standpoint of structure there is no question as to the position of man. Bone for bone and muscle for muscle he resembles the apes, and the finger prints of the chimpanzee cannot be distinguished from human prints. These primates are classified as follows:

Order *Primates*

I. Lemurs: really connecting links between insectivora and primates.
II. Anthropoids: Broad-nosed monkeys, tails often prehensile; spider monkeys, marmosets.
III. Narrow-nosed Apes:
  1. Tailed apes: Chests narrow. No vermiform appendix. Baboons.
  2. Tailless apes: Broad breastbones. Opposable thumbs. Gibbon, orang-utan, gorilla, chimpanzee.
  3. Man.

Of the great apes classified next to man, the gibbon has the longest arms and is a great tree-traveler. It is found in southeast Asia and adjacent islands. It stands erect, using its long arms to balance it as it walks. The orang-utan of Sumatra and Borneo is a heavy, sluggish, ground-dweller. On all fours it can scarcely bend back its head far enough to look straight ahead. The gorilla of Africa is the largest of all, weighing up to 360 pounds with a height of 5 feet 7 inches. Its life is almost wholly terrestrial. The chimpanzee of Africa, often 5 feet tall, has short arms, and stands next to the gibbon in time spent in the trees. Like the other apes its skull is short and that of the female most closely resembles the human skull.

Aside from the absence of a hairy covering man differs from the apes chiefly in his brain development. He stands more erect. The brains of the apes are well developed, averaging between 400 and 500 c.c. though chimpanzees with brains of only 200 c.c. have been found while the gorilla is known to have 610 c.c. at times. To meet human demands, brains of at least 960 c.c. are required.

Serology

Blood tests. Not long ago it was discovered that if human blood were injected into rabbits an anti-human serum would develop which would produce a white precipitate if brought into contact with human blood. This has proved to be a most efficient means of testing relationships. If this serum is put in contact with the blood of the apes a precipitate is formed, less quickly and in smaller amount. The blood of monkeys reacts still more slowly and to a smaller degree but the reaction may be traced even in the lemurs. No other blood gives the reaction.

Geographical Distribution

Similar regions in different parts of the earth have varying faunas and floras even though the same types of life be present. The elephants of Asia and Africa are not identical. The monkeys of Africa and South America are different. The desert regions of North America offer many local races of birds with color schemes peculiar to the area, such as the horned larks. Unless we assume special creations for the different continents we must assume some common ancestors and different variations. This is seen most clearly in isolated islands, a fact which early impressed Darwin when he visited the Galapagos. It is claimed that on Saint Helena, a thousand miles from Africa, there are: 129 species of beetles (all but one unique), belonging to 29 genera, of which 25 are unique; 20 species of land snails, of which 17 are unique; 26 species of ferns, of which 17 belong to unique genera.

Embryology

The science of development. Every one knows that an individual starts as a single cell and develops to mature form. The adult could not live under the conditions of its early existence. The growth of the organs of the body, such as the heart, curiously approximates the forms found in lower organisms. Hence arises the "recapitulation theory" which suggests that the individual recapitulates the history of the race. Often these early traits survive as vestigial organs of no present value or use. The horse shows its useless toes. At one stage the human embryo has a fish-like heart, brain, muscles, alimentary tract and even gill slits in the side of the neck. Later on it closely resembles the embryo of the rabbit or cat. Still later it is like the embryo of the ape and is covered with a coat of hair, which is shed, ordinarily, before birth. After birth the child holds its legs just as do the apes, and the spinal column is a single curve, as that of the ape, while in the adult man it has a double curve. The hairs of the human body have the same slant as those on the ape. The human infant for a few weeks after birth has a marked power of supporting itself by hanging on a stick with its hands.

Save in rare cases the human adult is tailless and the four or five lower vertebræ are fused but in fetal life the tail develops much as in other mammals and at one stage is longer than the legs. It is claimed that man has some 184 vestigial structures among which are the muscles which move the ears and the skin, the traces of an extra eyelid, the pineal gland, and, best known of all, the vermiform appendix, a doubtful honor which man shares with the simians. All animals have such vestigial organs and no explanation of their presence can be given save in terms of the evolutionary theory.

Genetics

The science of breeding. In as much as this is the center of interest in biology to-day its discussion cannot be limited to a paragraph and must form the subject of the next chapter. Suffice it to say that all the evidence it offers supports the idea of evolution.

Finally it should be noted that the dependence of the higher upon the lower organisms gives a certain support to a theory of evolution. Obviously, lower forms may live as parasites on higher animals and might conceivably arise later in some cases but the development of the higher forms without the prior presence of the lower to modify the environment and make the higher forms possible is simply unthinkable.

The Ladder of Life

At the bottom of the ladder of animal life we find the single-celled forms, such as the amœba common in vinegar, a membrane filled with liquid and enclosing a nucleus. In the ordinary sense of the term there is no specialization of organs.

Higher than the amœba stand the animals made up of many cells arranged in two layers. The hydra is a cylinder closed at one end where it is fastened to the rocks. At the open end of the cylinder are tentacles which by their motion cause currents of water to enter, thus introducing particles of food. The outer cells are protective, the inner layer digests the food.

Next in the scale are the worms in which we find a series of cylinders fastened together. These segments are much alike in structure and function, but with increasing specialization. This form characterizes the great mass of invertebrates. Crabs and lobsters as well as beetles and butterflies are built on this plan and are characteristic structures of the Paleozoic age.

The fishes are the first animals with backbones. The earlier types were covered with heavy coats of mail like the gar pike of our inland lakes. The shark represents, perhaps, the basic form, a great mass without sharp division of head, body and tail.

The next stage is represented by amphibious creatures which have gills during their early life. Typical of this form are the salamanders and frogs. These yield place to the reptiles, the lizard bearing close resemblance to the early types. Snakes are but degenerate lizards. From the reptiles it is but a short step to the birds, the scales being modified feathers, the forelegs to wings. The apteryx of Australia is a transitional form, while penguins and ostriches are wingless so far as flight is concerned. The Mesozoic age in which such types are dominant is thus one of transition.

Lowest among the mammals are the duckbill and its relative the echidna which superficially resembles the hedgehog. Both lay eggs. The next stage is represented by the marsupials, the so-called Tasmanian wolf, the kangaroo, the opossum of America. Here the young are born in extremely immature condition and must be carried in a pouch on the body of the mother. This brings us to the true placenta-bearing mammals divided into many orders. The great development of mammals took place during the Cenozoic or Tertiary age, though clear records of man are not found until the recent or Quaternary. Such is the scale from the lowest to the highest of living forms and this corresponds with the order of their appearance in the rocks.

Evolution Accepted

Such facts as those above indicated have forced thinking men to believe in a process of evolution. Against this interpretation there are no physical facts and its opponents are forced to arguments on theoretical or theological grounds. As a matter of fact, there would be little opposition to the theory if it were not for the inclusion of man as a product of organic development. But no physical reason for excluding him can be found. Evolution, then, is but a name for the processes of organic history. It carries no other meaning or implication. It must explain degeneration and retrogression as well. It has no moral connotation. It does not say that things are getting better or worse. It is but an attempt to understand and it represents the best thought of the best trained minds. As such it is likely to stand until further information makes revision necessary. Darwin studied for twenty years without publishing his ideas. Most of the opponents of evolution appear to publish for twenty years without preliminary study.

A tremendous amount of work remains to be done ere we shall have a satisfactory picture of the history of life on earth. Great areas like northern Asia where many of the early events seem to have taken place are almost unexplored. But the age of field work draws to a close and the interest of students has shifted. To-day they are studying heredity rather than evolution, and we must follow their trail.

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CHAPTER XI

HEREDITY

My gifts have come to me from down the years:
I am the son of huntsmen of old time,
The heir of timid virtue and of crime,
Offspring of sluggards and of pioneers,
Inheritor of juggled hopes and fears.
Some gave me purity, some gave the grime
Of damaged souls. Some of them helped me climb
Toward God. From some came smiles, from others
tears.

—Barker

Cells and Their Functions

While our understanding of the process of reproduction is far from complete we have found out more since 1850 than man had discovered in all the earlier time. Long ago man had learned that plants came from seeds; that animals reproduced "each after its kind"—lions begetting lions, and elephants, elephants. The Romans saw that some traits descended in family lines and spoke of certain families as *capitones* and *labiones,* just as modern Europeans have spoken

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The following is a key to the diagrams in this chapter:

□ —Males

○ —Females

◇ —Sex unknown

● —Stillborn or died in early infancy.

Shaded symbols represent individuals showing the character under discussion.

of the *Hapsburg lip*. The Israelites are said to have tried some breeding experiments with their cattle. Tacitus explained the uniform features of the Germans by claiming that they were of common and unmixed descent. Nevertheless, no great amount of information was secured until the microscope widened the range of human vision. So marvelous have been its revelations, especially since 1880 when aniline dyes came into use, that the center of biological interest has shifted from the adult to the cell.

As early as 1651 William Harvey asserted that all living organisms came from eggs. In 1665 Robert Hooke, examining a section of cork under the microscope, saw that it was made of "little boxes or cells distinguished from one another." By 1677 the human spermatozoön was discovered. In 1759 Wolff caught the idea that growth resulted from the multiplication of these small cells. In 1831 Robert Brown found that the plant cell had a nucleus. In 1835 Felix Dujardin discovered protoplasm, which is called "the material basis of life" and which always exists in cellular form. In 1838 Schleiden and Schwann demonstrated that plant and animal cells were similar in structure. In 1861 Gegenbauer showed that the eggs of all vertebrates were, in reality, single cells. This was found to be true of the spermatozoa in 1865.

Multiplication and Growth

From these discoveries man learned that all forms of life start as single cells and that growth is the result of their increase. But many forms do not enlarge—they simply divide and separate, and there are two cells where there was one before. When the cells divide (the process is called mitosis), in the multicellular forms, they do not separate but remain in close association in what we call a body. There comes also an increasing specialization in cell functions whose cause is unknown. A begonia leaf put in a saucer of water may start to grow and, if conditions are favorable, may develop several new plants. A post of willow put in the ground often develops into a tree but a post of white oak or chestnut does not. This means that in the plant world a part will often reproduce the whole.

Specialization of Function

When we come to the animal world a difference in this regard is evident. The lowly hydra can regenerate the whole from a part. A starfish torn in two may develop into two starfish. Some worms cut in two will develop into two individuals but if the scission is made too near the tail end of the worm we may get an individual with two tails. The halves of two worms may be grafted to form a whole. In one case two tadpoles of two different species were thus divided and grafted. It (they?) lived to become a frog whose body showed in its markings its curious origin. If a claw of a lobster is broken off a new claw will develop. A prawn will develop antennæ if the eyestalks are cut close to the body. No part of the body of the lobster, however, can reproduce the whole. The higher in the scale of life we go the greater the specialization. The skin cells of man will produce new skin, but nothing else; nerve cells will produce new nerve cells, but nothing else. The higher organisms, then, are made up of millions of cells in which specialization of function has gone so far that though they may reproduce themselves they cannot reproduce each other nor can they, singly or collectively, reproduce the whole. This function is reserved for certain cells, which we may think of as non-specialized and taking no part in the maintenance of the body, to which we apply the name germ cells. We have to distinguish, therefore, body cells and germ cells.

Chromosomes

In 1883 Van Beneden, by using aniline dyes, discovered that the nucleus of the cell had a definite and complicated structure. To-day we know that each nucleus contains a number of filaments (called chromosomes, *i. e.,* color bodies). These are so delicate and perishable and often so intertwined that accurate count and continued observation have been most difficult. In spite of this it has been found that their number is pretty definitely fixed in any given species but varies greatly in different species. In some worms the total is as low as four, in the house fly, twelve; in many grasshoppers, twenty-four; in the rat, thirty-six; in man, forty-eight. In appearance they vary greatly also and the differences between the chromosomes of different species are constant.

If one watches a single-celled form of life for a few minutes it will be noticed that the wall of the cell is gradually constricting until the two halves finally separate and two cells are swimming in the field of the microscope. It is now known that in this process of mitosis the chromosomes arrange themselves between two nuclear points and then each chromosome splits lengthwise. A half of each chromosome is then attracted to each nuclear point so that when the cell finally divides both daughter cells have a complete equipment of chromosomes—and have, as a rule it would appear, the same equipment. What causes this cell division no one knows. Bateson has well said: "The greatest advance I can conceive in biology would be the discovery of the nature of the instability which leads to the continual division of the cell. When I look at a dividing cell, I feel as an astronomer might do if he beheld the formation of a double star; that an original act of creation is taking place before me." [1]

Body Cells and Germ Cells

From the unicellular types which separate and pursue their individual ways we pass to simple conglomerations in which each cell maintains its own powers and, if the colony breaks up, as often happens, may start another. Gradually this leads to a more definite body formation with the increasing specialization already mentioned. Thus arises the contrast between body and germ cells. Even after specialization has started it seems possible in some of the lowly forms for a cell to retrace its steps and replace other cells if some accident has befallen them. In the higher forms this power is lost. In the insects, for instance, only a few generations after the first division of the fertilized ovum certain cells are set aside and thereafter take no part in the development of the body but become the ancestors of the germ cells. It is impossible to see a similar process taking place in the embryos of mammals but there is every reason to suspect that it occurs. These first germ cells keep on increasing in numbers in parts of the digestive tract until later they move into the sex organs as they develop. There is reason to believe that a chicken on hatching already contains in its body all the eggs a mature hen will lay. A girl, at birth, contains every ovum she will ever produce.

When it was realized that all animals came from fertilized eggs it was assumed that this egg contained a very minute model of the adult. The moment the structure of the cell was known such an idea became untenable. There is nothing in the cell which bears any resemblance to any part of the body. Something there must be which has the power of growing into the familiar bodily forms. Careful observation has indicated that this power resides in the chromosomes and they are often called the "bearers of heredity." One is tempted immediately to follow the example of the chemist and to think of some biological atom as the unit of life. There is no objection to this if we safeguard ourselves by remembering that there is no evidence at hand to show that this unit lies in any given chromosome. Much remains to be learned on this point. Various names have been applied to the source of this power, such as factor, determiner, or, to use the one most current to-day, gene. A host of questions arise in our minds as to the powers and functions of chromosomes, their relations to each other and as to whether their characters are fixed or changing. But these are the central points of interest in current biology about which there is much debate and for their discussion the reader must turn to technical works.

The concept of a little "homunculus" in the human germ cell indicates that not long ago men thought in terms of a finished product, of the organism as a whole. The observations and keen speculations of a few men caused a complete shift in this regard, to a picture of a whole made up of parts.

THE EXPLORERS OF HEREDITY

In the year 1900 the scientific world was astonished to learn that three men, working independently, had observed similar phenomena in the variation of plants, and, curiously enough, had each rediscovered an earlier student of the same phenomena, whose writings had hitherto been unknown in as much as they were published in a rather obscure journal. These three men were De Vries, Correns and Tschermak.

De Vries

The Dutch botanist, Hugo de Vries, in the nineties, found some specimens of a common American plant, the evening primrose (*Œnothera lamarckiana*) which had escaped from an Amsterdam garden. He began to cultivate them and found that the seeds produced plants, some of which were like the older form, and some of which were quite different. On planting the seeds of these aberrant types he found, to his surprise, that in the main they bred true and did not revert to the older. One very large form (called gigas) appeared three times although the seeds from which it came had come from the ordinary lamarckiana for three generations. In 1897 the self-fertilized seeds of this gigas produced over 450 plants which, with one exception, were of the gigas type. This one exceptional plant, best described as a dwarf gigas, gave seeds which when planted again produced the dwarf type. The commonest new form produced by the lamarckiana seeds was a plant with brittle stems and red veins, which appeared sixty-six times and whose seeds bred true to the new type. Here, then, were several new species apparently, appearing without warning and breeding true. What could be the explanation? St. Hilaire at the end of the eighteenth century on rather meager grounds had suggested that evolution had taken place by larger steps than was thought, but the prevalent opinion, shared by Darwin, was that variations were usually very small and caused in some way by the environment. Darwin knew of the sudden, marked variations, in his day called sports, but had considered them of little importance as he thought they would revert or be swamped by breeding again with the older types. But what environmental influence could produce such sudden breaks as those found by De Vries and how could one explain their permanence in self-fertilized plants? The result was that De Vries got a picture of a "discontinuous" variation by means of sudden "mutations," quite different from the older idea of continuous variation even though the point finally reached be the same, as may be shown by a simple diagram:

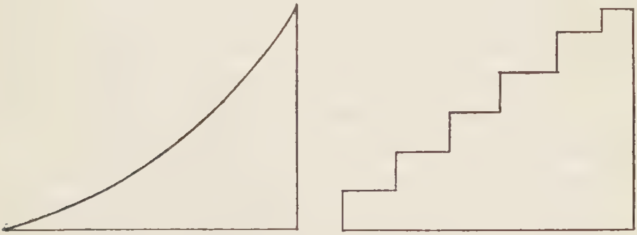


FIG. 16. CONTINUOUS VARIATION DISCONTINUOUS VARIATION

Mendel

Gregor Mendel (1822-1884) published in 1866 an account of a long series of experiments in breeding sweet peas.[2]

Nägeli was the only prominent botanist among Mendel's contemporaries who knew of this study and he did not catch its significance. In the light of later discoveries it assumed great importance.

Mendel found that instead of thinking of the entire plant as a unit he had to consider each plant as made up of units. He found in the pea seven of these unit characters on which he could depend: (1) the form of the ripe seeds; (2) the color of the substance of the pea; (3) the color of the seed coat; (4) the form of the ripe pods; (5) the color of the unripe pods; (6) the position of the flowers; and (7) the length of the stem. Moreover, these characters appeared to go in pairs: the seeds were either smooth or wrinkled; in color, they were either yellow or green. If two plants, differing in respect to any of these characters, were crossed the next generation did not show a blend but, without exception, one but not the other of the two types. To the character that appeared he gave the name dominant; to the one which disappeared the name recessive. He seems to have thought of some sort of a contest within the germ cell, the stronger character manifesting itself. Mendel made some fifty-eight crosses on ten plants and found that yellow was dominant over green in every instance. He found that the smooth, round seed coat was always dominant over the wrinkled. Here was a puzzle. What had become of the character that disappeared? The hybrid plants were allowed to self-fertilize. They produced 8,023 seeds, of which 6,022 were yellow and 2,001 were green. This, be it noted, is a ratio of about 3 to 1. Of the yellow-coated seeds 519 were planted and allowed to go to seed; 166 of them produced yellow seeds only, while 353 produced both yellow and green. The hybrids of the round and wrinkled sorts produced 5,474 round seeds and 1,850 wrinkled, while the hybrids of the tall and short varieties produced 787 tall and 277 short plants; in both cases approximately 3 to 1. The recessive character is thus not lost or destroyed. It reappears again in a certain percentage of the offspring.

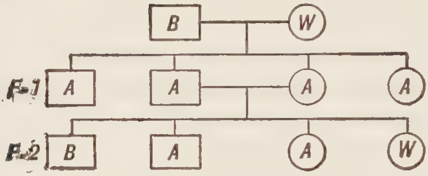
Correns

Correns found that if he crossed the white variety of the four-o'clock with the red variety all the hybrids were pink, but that the self-fertilized seeds from these pinks produced white, pink and red flowers in the ratio of 1 to 2 to 1. At first glance this appears to be different from the results obtained by Mendel but in reality it is the same, the principle being brought out more clearly by the fact that the hybrid is of different color from the pure dominant.

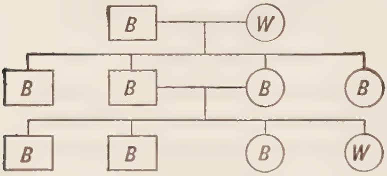
To show what happens in these two cases we may compare them in the following diagrams, taking two animals as our subjects. About 1836, black and white Spanish chickens were introduced into England. The crossing of birds of the two colors produced a finely mottled, gray bird known as the blue Andalusian. To the disgust of the chicken fanciers when birds of this blue generation were bred to each other and the eggs hatched only about half of the next generation were blue, an approximately equal number being either white or black. In the guinea pigs, however, the hybrid generation reproduce only the dominant black. In the diagrams the number, order, and sex are arbitrarily arranged.

It will be noted that the chickens show in the second filial generation the 1 to 2 to 1 ratio obtained by Correns with the four-o'clocks, while the guinea pigs seem to give the 3 to 1 ratio of the sweet peas grown by Mendel. By breeding the individuals of this second filial generation the true facts appear. The black chickens or black guinea pigs mated with pure black will give black offspring only, while the recessive whites mated with whites produce whites only. The blue hybrid chickens, or the other two guinea pigs, if interbred, reproduce both types of the originals as well as the hybrids.

We may follow Mendel's work a step further and note what happens when plants are crossed which differ in two sets of characters, recalling that round is dominant over wrinkled, yellow over green. Four types of seeds are possible. Actual observation shows that we shall obtain nine yellow round seeds; three yellow wrinkled; three green round; and one green wrinkled. This ratio of 9 to 3 to 3 to 1 has been found to hold in other experiments.



SPANISH CHICKENS



GUINEA PIGS

Fig. 17. Color inheritance

Mendel was keen enough to see that the explanation of these results must lie in the nature of the germ cells and not in environmental conditions. He could not give a complete answer to the questions raised, but he did show that the factors causing these phenomena were separately heritable. The rediscovery of his work in connection with that of the botanists just mentioned gave a great stimulus to the study of heredity and the phenomena under discussion are called Mendelian in honor of their first discoverer. Again, as so often, it happens that an earlier student had seen the same thing without being impressed thereby. In 1820 John Gross of Devonshire, seeking a new variety of pea, had observed the results of crossing different types but had not caught the existence of any underlying law.

The Mechanism of Heredity

If we assume, then, that there is in the chromosomes a determiner for the different characters and do not forget that each individual gets the chromosomes of his germ cells from both parents, we may hazard an explanation of the process of heredity. Consider the case of the guinea pigs. The black pig came of pure black ancestry and we may say that he was duplex or homozygous in so far as color is concerned. The white pig had a white ancestry and was likewise duplex. Now when these pigs are mated every ovum of the mother carries a determiner for white and every sperm of the father a determiner for black. Hence, in so far as color is concerned, all the offspring are simplex or heterozygous, and all are black as black is dominant over white. When these hybrids are mated, however, the chances are that out of four possible combinations, black will join with black once; black with white, twice; and white with white, once. Such a result is based on many matings, of course, for one case is not decisive. A cent thrown into the air may come down "heads-up" ten times in succession, but out of a large number of throws heads and tails will be about equal.

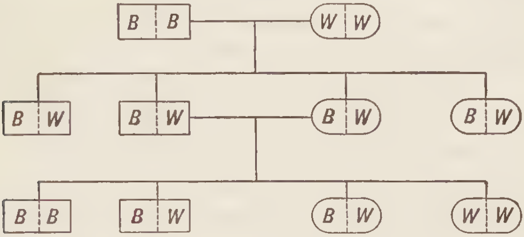


FIG. 18. SUGGESTED EXPLANATION OF COLOR INHERITANCE IN GUINEA PIGS

In as much as the pig at the left in the third generation is duplex black evidently it cannot produce white if mated with another pure black; while the one at the right is duplex white and cannot produce black again if mated with white. The two pigs in the middle are simplex and will therefore produce both black and white if mated.

Unit Characters

To Mendel, then, we owe the idea that the body is made up of a number of unit characters which to some extent at least may be separately inherited and put into varying combinations. Evidently the determiners must exist in pairs in as much as they come from both parents. The uniting of any given male cell with any given ovum being assumed to be a matter of chance, the percentage of any given type of offspring is solely a question of mathematical average. The larger the number of cases the more closely will the actual count approximate the ideal. On these questions a great deal of evidence has accumulated since 1900.

The Germ Cell

This evidence has supplemented some of the claims made as early as 1890 by one of the greatest of the successors of Darwin, August Weismann. After 1867 Weismann had undertaken to develop a suggestion made by Virchow in his *Cellular Pathology* of 1858. In as much as every individual starts life as a single cell, and in as much as these cells all come from those of earlier generations by the process of division, Weismann became convinced that it was to the germ cells, not to the body as a whole, that we must look for the facts of heredity and variation. He came, therefore, to think of the germ plasm as something independent of the body in which it was housed and which was passed along, generation after generation, practically unchanged. He thought that within the germ cells there must be determiners of some sort for the various parts of the body and saw that, if this were true, some of them would have to be discarded or else they would double each generation, which seemed most unlikely. This was soon found to be true.

The life history of the germ cell is somewhat different from that of body cells. Like them it increases in number by simple division. There comes a time when a ripening or maturing division takes place. Take the human spermatozoön as an illustration. It starts with forty-eight chromosomes. There comes a mitosis in which the chromosomes do not split but separate, one of each pair entering each daughter cell. Thus we have two cells, each with twenty-four chromosomes. Here their career ends unless they have an opportunity to unite with an egg which has undergone a similar reduction of chromosomes, and thus start a new individual whose cells contain original number of forty-eight chromosomes.

The Gene

Many questions occur to us at once, most of which cannot be answered at present and are too involved for discussion outside of a technical treatise. What happens in this reduction division? Do the same chromosomes always associate? Are new combinations possible? Can there be any trading of qualities by the chromosomes? If the same chromosomes are not always found together and if interchanges take place, a very plausible explanation of the means by which variation is effected, rather than caused, is suggested. We know, to-day, that some of these things do occur and by the close study of many thousands of lower organisms, the frequency of given variations may be predicted in some cases. This has given rise to the theory of the gene, which is best stated by one of the men chiefly responsible for it.

> The theory states that the characters of the individual are referable to paired elements (genes) in the germinal material that are held together in a definite number of linkage groups; it

states that the members of each pair of genes separate when the germ-cells mature in accordance with Mendel's first law, and in consequence each germ-cell comes to contain one set only; it states that the members belonging to different linkage groups assort independently in accordance with Mendel's second law; it states that an orderly interchange—crossing-over—also takes place, at times, between the elements in corresponding linkage-groups; and it states that the frequency of crossing-over furnishes evidence of the linear order of the elements in each linkage group and of the relative position of the elements with respect to each other.

These principles, which taken together, I have ventured to call the theory of the gene, enable us to handle problems of genetics on a strictly numerical basis, and allow us to predict, with a great deal of precision, what will happen in any given situation. . . .[3]

The work of the last few years in genetics had made it clear that, despite the occurrence of the same number of chromosomes in related species and even in entire families and orders, it is hazardous to assume that the chromosomes, even in closely related species, are always identical as to their genes. The genetic evidence is beginning to make clear that readjustments may take place both within the chromosomes, where groups of genes may come to lie in reversed order, and between different chromosomes, where blocks of genes may be shifted, without giving a measurable difference in size. Even whole chromosomes might be recombined in different groupings without changing the actual number. Alterations of these kinds will affect profoundly the linkage relations, hence the modes of inheritance of the various characters, without, however, changing the total number or kinds of the genes involved. Unless, therefore, the cytological observations are checked by genetic studies it will always be unsafe to assume that identity in number of chromosomes means a correspondence in grouping of the genes.[4]

Linked Characters

It appears from the studies of Morgan and others that the so-called unit characters are not wholly separately inherited as Mendel thought but that they are tied or linked together in groups.

By linkage we mean that when certain characters enter a cross together, they tend to remain together in later generations, or, stated in a negative way, certain pairs of characters do not assort at random.

It would seem, then, that so far as linkage holds, that there are limits to the subdivision of the germinal material. For example in the vinegar fly, Drosophila melanogaster, there are known about 400 new mutant types that fall into only four linkage groups.

These groups contain 150, 120, 130 and 3 characters respectively.

The method of inheritance of linked characters is given in the following example. A male Drosophila with four linked characters (belonging to the second group), black body color, purple eyes, vestigial wings, and a speck at the base of the wings, is crossed to a wild type female with the corresponding normal characters, that may be called gray body color, red eyes, long wings, and absence of speck. The offspring are wild type. If one of the sons is now crossed to a stock female having the four recessive characters (black, purple, vestigial, speck), the offspring are of two kinds only, half are like one grandparent with the four recessive characters, and the other half are wild type like the other grandparent.[5]

Recent studies give us a picture of

a great number of discrete packets of diverse materials, embedded in a less diversified mass of material. The masses formed by the groupings of these packets are visible under the microscope as the chromosomes. The number of different kinds of packets that go into the beginning of any individual is very great, running into the hundreds of thousands. They are not massed in a haphazard way, but are arranged in a definite manner; so that a young organism is like a well organized chemical laboratory with many reagents so arranged in containers as to react in an orderly way, producing a definite and harmonious result. . . .

The disposition of the chemical packets, or genes, is known to be at the beginning that of a double serial arrangement like a pair of strings of beads; each chemical has its precise and

> practically invariable place in the series. For each packet in one of the two strings there is a corresponding packet in the other, so that the whole forms a set of pairs of packets. . . .
>
> One parent gives to any particular offspring one packet only of each of its pairs. The other parent supplies the corresponding second packet of the pair, so that the offspring has again the full complement of pairs. The first of the rules of distribution discovered was the so-called Mendelian Law; it is the rule according to which the two packets belonging to the same pair are distributed. But when we take into consideration the interlocations of packets belonging to different pairs, a whole set of rules is discovered covering the distribution of all the packets. These have been worked out in recent years; they are of equal importance with Mendel's law. In essence these laws are simple; . . .
>
> The first precise discovery made was, essentially, that when a single one of the packets is exchanged for another, some later character is changed. . . . Characters changed by altering a single packet were the so-called "Unit characters" of Mendelism.[6]

It is not to be assumed that any given unit character is caused by any given gene. In one sense, "each gene may have a specific effect on a particular organ, but this gene is by no means the sole representative of that organ, and it has also equally specific effects on other organs, and, in extreme cases, perhaps on all the organs or characters of the body."[7]

In the first flush of enthusiasm over Mendelian inheritance many extreme claims were made with reference to unit characters which later observations have not supported. There has come a considerable reaction against a too-exclusive emphasis on specific units. As Jennings says:

> These facts—the relation of single packets to particular later characteristics—gave rise to a general doctrine, a philosophy of heredity and development, a doctrine which had and still has a very great influence on general views of life. It is to this doctrine that the prevailing ideas of heredity and environment, as to the relative powerlessness of the environment, are due. But it has turned out to be a completely mistaken one. This fact has not come to general consciousness; the doctrine con-

tinues to be a source of mystification and error. Its complete disappearance would mean a very great advance in the understanding of life.

But this theory of representative particles is gone, clean gone. Advance in the knowledge of genetics has demonstrated its falsity. . . . It is not true that particular characteristics are in any sense represented or condensed or contained in particular unit genes. Neither eye-color, nor tallness, nor feeble-mindedness, nor any other characteristic is a unit character in any such sense. There is, indeed, no such thing as "unit character" and it would be a step in advance if that expression should disappear.[8] . . .

The genes then are simply chemicals that enter into a great number of reactions, the final upshot of which is to produce the completed body. The characteristics of the adults are no more present in the germ cells than are those of an automobile in the metallic ores out of which it is ultimately manufactured. To get the complete, normally-acting organism, the proper materials are essential; but equally essential is it that they should interact properly with each other and with other things. *And the way they interact and what they produce depends on the conditions.*[9]

Mutants

Without any further attempt to trace the mechanism of heredity, let us turn to other matters. The practical man wants to know if there is record of any mutant forms which have been of any special value. Among animals may be mentioned the ancon sheep, formerly highly esteemed, as well as the better known merino of to-day. Hornless cattle are mutants; so are tailless cats. In the vegetable world some of the more important mutants are the Concord grape and its later mutant forms, Worden's, Moore's Early and Pocklington. Nectarines are mutants from peaches; apricots from plums. The Hubbard squash is a mutant. Many others might be named, and the list of mutant flowering plants is long. Nevertheless the great bulk of the mutations are very small rather than large deviations from the older types.

Sex Linkage

It will be recalled that one of Morgan's group of mutants among the vinegar flies contained some 150 characters which were sex-linked. The eyes of this fly are normally red, but occasionally a male appears which has white eyes. Morgan found that a white-eyed male crossed with a red-eyed female produced a generation with red eyes, but if this generation was interbred, one-half of the resulting males would have red eyes, one-half, white. To get a female with white eyes it was necessary to cross a white-eyed male with a female descended from a white-eyed male, and then one-half of the females would have white eyes. This is about the case with the inheritance of color blindness among humans.

Dorset horned sheep crossed with the hornless Suffolks produce hybrids in which all the males have horns but none of the females. That is, the male is horned if the factor comes from either parent while the female is hornless unless it comes from both.

Pure barred-rock chickens breed true among themselves. If the males are crossed with other breeds only barred offspring will result; but if the females are mated with a nonbarred breed, approximately one-half of the next generation will be barred, the other half, not. Moreover, the barred ones will be found to be males, the nonbarred, females.

Such phenomena find their probable explanation in the behavior of the chromosomes. Many similar instances can be found among men and sex itself seems to be explicable on Mendelian grounds.

The discovery of the rôle of the chromosomes (in this discussion all reference to the rest of the cell is omitted though it may, and probably does, play a real part in actual life) throws light on a long debated question.

Inheritance of Acquired Characters

Weismann challenged a hoary belief when he denied the possibility of the inheritance of acquired characters which earlier men had considered almost self-evident. Astonished, the scientists started out to demonstrate his error but in the forty years since the challenge was issued not a single clean-cut case has been found. The results of the most noted series of experiments, those of Brown-Sequard, were not secured by others who repeated them, and the revelation of the dishonesty involved in the most notorious cases, those of Kammerer, led to his suicide. Yet the belief will not down even in scientific circles.

The adaptation of organisms to their environment is so detailed and complete, the type of life changing with the environment as revealed in geological strata as well as in different regions of earth to-day, that the suggestion of a causal factor is almost inevitable. What causes variation of unicellular forms unless it is something from without? There is no adequate answer. But when a demonstration is attempted only negative results ensue.

Weismann, having shown that we must look to the cell for the solution of the problems of heredity, emphasized the "continuity of the germ plasm," that is, the descent, generation after generation, of germ cells from germ cells. His idea may be shown by the diagram in Figure 19. Though the cells come through the body of the adults they are produced by earlier germ cells. No changes in body cell, then, could produce modifications in the structure of the germ cells.

In this diagram the successive generations are represented by the corner line. The upper groups of figures represent the qualities and attainments of the various individuals. Each generation is derived, however, not from these personal peculiarities, but from the germ cells which continue with little, if any, change from one generation to another.

To begin with let us see what our terms mean. We know no more of the *cause* of variation than we do of the cause of original creation. We know the *fact* and something of the process and machinery—that is all. Obviously it is quite as possible to cripple or destroy a single cell as to do the same to a great organism. We may be, and are, able to modify a single cell by changing its environment. This we shall discuss shortly. Evidently we may change an organism in many ways, but how can we change the germ cells lying deeply imbedded and protected within that organism?

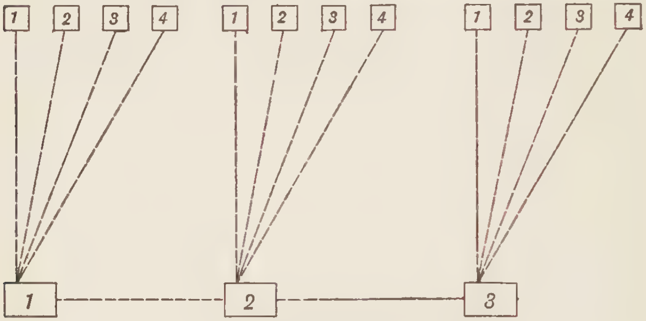


FIG. 19. THE RELATIONS BETWFEN SUCCESSIVE GENERATIONS

(Modified from Wilson.)

When we speak of acquired characters we refer to some sort of a change in the arrangement of the body cells of an individual. The phrase cannot be used to include the changes coming to a species through variation. The older generation, Darwin included, believed that such body-cell changes affected the germ plasm of the individual and Darwin tried to explain it by little gemmules sent from the affected parts to be incorporated in the germ cells. But such gemmules have never been found. Moreover, there is no organic connection between the body and the germ cells it contains. The germ cells live in the body just as countless thousands of parasitic cells live in the intestinal tract. The germ cells get their nourishment from the blood stream just as do the body cells. There is no nerve connection between the body and the germ cells. Modern anatomy knows nothing of any mechanism for carrying any body-cell change to the germ cells. Our evidence goes even further.

Body-cell changes must fall into one of three categories. They are improvements, or mutilations, or a matter of indifference. For practical purposes we are limited to the two first. If a man through care and exercise develops his body or any part thereof we may call it an improvement. What is the evidence that man of to-day is any stronger than were his ancestors thousands of years ago? Mental development has distinguished man but teachers find few Aristotles in their classes and students find few Socrates on the platforms. The evidence from mutilations is even more conclusive for some of them have been practiced for many successive generations. No change produced by man on his body seems to affect later generations. The hymen persists in virgins. The hair and nails continue to grow though cut, broken, or bitten off for ages. Bones have been changed by malnutrition, by pressure or accident; feet have been bound; circumcision practiced for centuries, but each generation must submit to the process anew if it is to have corresponding modifications. Neither anatomy nor history, then, gives any support to the belief.

External Influences on the Germ Cell

A few paragraphs ago it was stated that germ cells might be modified directly just as the body is helped or harmed by the things we eat. It is quite possible, then, that we may influence directly the germ cells within our bodies. No one has suggested any way of improving them but several ways of injuring them are known. For instance, they may be destroyed by some disease like gonorrhea. What evidence is there at the present time as to the ways of directly affecting the germ cells?

Tower exposed potato beetles to unusual conditions of light, moisture, etc., and noted changes in the young beetles hatching from the eggs laid subsequently. No given change resulted but there was unusual variation in the color pattern. These changed forms thereafter bred true; that is, they acted like mutants.

Mice exposed to X-rays showed in the second generation various deformities in legs, feet, eyes and jaws which proved to be transmitted.

Stockard and his associates made a long-continued investigation of the effects of alcohol on guinea pigs which had been tested in advance and found to produce normal offspring. They were compelled to inhale the fumes of alcohol as often as six times a week for over five years, never being completely intoxicated, and with little apparent harm to the individual. One male, treated regularly, lived to be seven years old. In no case was the individual harmed when it was three months old at the start of the experiment.

The experiment produced, however, a very high percentage of sterility, stillborn offspring, or short-lived weaklings subject to spasms and nervous defects. This was true even if the males alone were exposed to the alcohol.

Raymond Pearl studied the effects of alcohol on chickens and became convinced that "the offspring of the alcoholists, as a class, are indubitably differentiated from the offspring of the non-alcoholists."[10] The proportion of fertile eggs was reduced whether one or both parents were treated. He thought that the weaker stock was eliminated and found no ultimate degeneration.

Writing of these two experiments, Stockard says:

> It seems to us in keeping with what is known of biological reactions in general and the guinea-pig histories in particular to take the following position. The alcohol treatment acts on

the germ cell population of both fowls and guinea pigs in such a manner that the weakest or least resistant ova and spermatozoa die from the effects of the treatment as germ cells without taking any part in zygote formation. The somewhat more resistant ova and spermatozoa are greatly injured although still capable of forming zygotes. The zygotes, however, are so defective as to be capable of only a short period of development and die during stages of development too early to be definitely detected by gross examinations of either the fowl's egg or the mammalian mother. Still other embryos are capable of development to later stages and are actually found dead, not only as the youngest embryos to be identified, but from these early stages there occurs a continuous series of prenatal deaths up to the full-term still-births. Immediately after birth the postnatal mortality is greatest and gradually decreases until those specimens capable of reaching maturity may often enjoy a comparatively long life.[11]

It is dangerous to jump to conclusions about this work of Stockard. After several generations had passed he discovered strains coming from the alcoholized stock which were hardy and long lived. As he has stated elsewhere: "It seems quite definite from the experiments on several kinds of animals by a number of investigators that alcohol does have some selective effect, as Raymond Pearl first clearly pointed out, and it does tend to eliminate more promptly the weak and undesirable germ cells rather than the strong. Alcohol may thus actually improve the race." [12]

Positive results have been secured in other cases. Lead acetate given to male rabbits and to roosters has caused sterility or increased the death rate of offspring. Guinea pigs treated by X-rays produced a strain which became sterile. The pulverized lens of rabbits injected into fowls has caused eye defects. Plant ovaries treated with potassium iodide have produced new strains.

It is well known that changes of some sort are produced in unicellular forms grown in different media. The smallpox germ loses most of its dangerous qualities when grown in animals. The diphtheria bacillus grown in milk and in peptone broth agar under the same temperature produces differences recognizable under the microscope in twenty-four hours. Whether these changes are in the chemical make-up of the cell or in its structure we need not stop to speculate. All the effects we can produce on the germ cells of mammals may be defined as crippling.

The significance of all this is that aside from the toxins of disease, and aside from certain poisons, say alcohol, which may be inhaled or imbibed, it is difficult to imagine how the germ cells of the higher animals can be reached by outside influences. Moreover, while crippling or extinction may result, in no case is there evidence of any variation or modification resulting where the stock has been able to survive the exposure.

Furthermore, it is obvious that any direct change produced in germ cells is different from a body-cell change which later in some fashion is assumed to affect the germ cells. The very point of the discussion is whether variation is produced by changes starting in the germ cell as a result of some reorganization of material or starting first in the body cell. The evidence is all in favor of the belief that germ-cell change comes first. What causes it we do not know.

It should not be forgotten that the offspring of every mammal have a long prenatal life in the body of the mother, fed by a process of osmosis from her blood. The characteristics shown at birth may be due to exposure to poison or disease during fetal life. That is, they may be environmental and not hereditary. For the sake of clearness of thought, heredity must be limited to the characters coming from germ cells and not made to include all things which may in some way be transmitted from parent to child.

Heredity and Environment

As a matter of fact, heredity and environment are complementary terms. As Jennings has said: "Any characteristic requires for its production an adequate stock of chemicals and an environment adequate for its production through proper interaction of these chemicals with one another and with other things. In these senses all things are hereditary and all are environmental, but no character is exclusively hereditary or environmental."[13] In happy fashion he tells of the water-living salamanders of Mexico (axolotls) which have gills. If forced to live in decreasing supplies of water they take to the land, shed their gills, and become the air-breathers formerly classified as a separate species (Amblystoma). Moreover, each type will reproduce itself.

The most spectacular evidence, perhaps, as to the immunity of cells from environmental change is shown in the following case:

> A female albino guinea-pig, just attaining sexual maturity, was by an operation deprived of her ovaries, and instead of the removed ovaries there were inserted into her body the ovaries of a young black female guinea-pig, not yet sexually matured, aged about three weeks. The grafted animal was now mated with a male albino guinea-pig. From numerous experiments with albino guinea-pigs it may be stated emphatically that normal albinos mated together, without exception, produce only albino young, and the presumption is strong, therefore, that had this female not been operated on she would have done the same. She produced, however, by the albino male three litters of young which consisted together of six individuals, all black. The first litter of young was produced about six months after the operation, the last one about a year. The transplanted ovarian tissue must have remained in its new environment, therefore, from four to ten months before the eggs attained full growth and were discharged, ample time it would seem, for the influence of the foreign body upon the inheritance to show itself were such influence possible.[14]

In the light of all the evidence now at hand we are compelled to say that the old "use and disuse" theory, no matter how stated, does not hold. Training and education leave the race stock unmodified. Neglect and bad conditions cripple the individual, not the race. After all, this is encouraging. When we think of all the accidents which have befallen our ancestors we must be grateful that their results have not been cumulative. Our faces are not pock-marked; our bones are not misshapen; our brains still function. It is easy to harm the individual; nature looks out for the race. All that man can do is to see that each generation has a fair chance—the rest is beyond him.

Up to this point our evidence has been drawn from the study of the cell or from experimental breeding—cytology and genetics. There remains to be noted the evidence which can be secured through statistics.

Biometrics

In 1846 the Swiss Quetelet in his *Letters on the Theory of Probability* applied statistics to biological problems and offered evidence to show that this theory would explain the phenomenon of variation. This method was taken over by Francis Galton, a cousin of Darwin, and given wide application. Its chief advocate in the last generation has been Karl Pearson to whom we are indebted for the name biometrics. It is obvious, of course, that the experimental breeder must use statistical methods in tabulating and comparing his results. Masses of people are not under laboratory control, however, but if they are to be studied our only hope for anything more than vague impressions lies in the exactness of mathematical processes. Each method of study has its own limitations. Biometrics will tell us what will happen *on the average,* not what to expect in any given case. A map of current labor conditions in the country shows plenty of work in certain states and a surplus of labor in others. Yet the condition of a given man may be bad in the first states and good in the second.

By the use of such methods we may get fairly accurate comparisons of different groups. Evidently we deal with results rather than causes but it is important to know results and statistical methods are finding increasing employment.

Attention has already been called to the constant and intimate association of heredity and environment. This association will be very confusing to the student unless care is taken to avoid error. Originally the word inheritance referred to the property received from the previous generation. This we may call its legal meaning. If social customs decree that the bulk of the property shall go to one son, he may prosper though weak physically and mentally, while the rest may suffer though well-equipped in these regards. Hence, great social differences easily arise. Because a child is born into a given social environment from which he gets his language, customs and standards, we say that he inherits them. This is social heredity, and obviously, is very different from physical heredity. The medical man often uses the word hereditary in the sense of congenital, the *time* a character is seen, leaving its *origin* unsettled. The doctor further offends by speaking of certain diseases as inherited when he means that they are transmitted to the child before birth. The problems involved are great enough without the use of ambiguous terms. We might avoid much sterile discussion as well as misunderstanding if we would adopt (and stick to) a definition such as that given by Conklin: "Heredity may be defined as the appearance in offspring of characters whose differential causes are found in the germ cells."

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CHAPTER XII

PROBLEMS OF HUMAN HEREDITY

> Lord, I find the genealogy of my Saviour strangely checkered with four remarkable changes in four immediate generations.
>
> 1. Roboam begat Abia; that is a bad father begat a bad son
> 2. Abia begat Asa; that is a bad father begat a good son
> 3. Asa begat Josaphat; that is a good father begat a good son
> 4. Josaphat begat Joram; that is a good father begat a bad son.
>
> I see, Lord, from hence, that my father's piety cannot be entailed; that is bad news for me. But I see also that actual impiety is not always hereditary; that is good news for my son.
>
> —Thomas Fuller, *Scripture Observations.*

No two human beings are exactly alike, not even identical twins. Our friends seldom make even momentary mistakes in identifying us though rarely have they consciously sought to know our physical details. These differences extend to all parts of the body including the brain and nervous systems. Some of them are due to environmental conditions; others to heredity. Yet, we are in the habit of assuming identity of qualities in our systems of law, ethics, and customs, though we make countless exceptions in actual life. What then is a normal man? Ask a friend this question and see if his definition does not apply to the *ideal* rather than to the *normal.* The point is that in our mental images of people we exclude as much as we include. We prefer this to that;

we emphasize this and not that. Prejudice and sentiment confuse our judgments. Social tradition blinds our eyes to facts. When we enter the field of human heredity it is well to keep these habits in mind. To avoid (possibly to provoke) discussion let us define a normal man as one who can adjust himself to his social environment and earn an honest living.

INHERITANCE OF PHYSICAL QUALITIES

The evidence indicates that any inborn trait can be passed along, generation after generation. There is much less certainty as to unit characters in man than there was in the early days of Mendelian enthusiasm and practically all of these now recognized are undesirable abnormalities. There is no reason to doubt that many characters follow the Mendelian rules of inheritance, but Conklin's warning should be remembered:

> When we come to the development of more complex things such as temperament, feeble-mindedness, insanity, personality, we are dealing with the most complex phenomena in all the world—inconceivably more complex than any of the problems of astronomy, physics or chemistry. If eye color in the fruit fly is dependent upon a large number of inheritance factors, as Morgan and his pupils have shown to be the case, how much more probable is it that epilepsy, feeble-mindedness, genius and insanity are dependent upon a still larger number of inheritance factors, as well as upon an innumerable number of environmental causes? We may be sure that when the whole "alphabet of degeneracy from alcoholism to wanderlust" is attributed to the lack of a single hereditary factor, there has been a pitiful failure to recognize the complexity of the phenomena in question.[1]

It is true that there seem to be a few simple cases. Blue eyes act as recessives and brown eyes as dominants, as a rule. Fourteen hundred Danish children were examined by Winge with the following results:

INHERITANCE OF EYE COLOR[2]

MARRIAGES	NUMBER OF CHILDREN			TOTAL
	Blue	Brown	Grayish-Green or Bluish-Green	
Blue x Blue.....	625	12	7	644
Blue x Brown...	317	322	9	648
Brown x Brown.	25	82	....	107
TOTAL	967	416	16	1399

In the main the above results tally with the Mendelian scheme if the brown-eyed parents are carrying a gene for blue, *i.e.,* if they themselves are hybrids in so far as eye color is concerned. Assuming that the eye colors were correctly determined, the twelve children with brown eyes coming from two blue-eyed parents do not conform. Dark hair also seems dominant to light; curly hair to straight.

Such phenomena cause no special concern for they seem to have little importance. We see both blue-eyed and brown-eyed people in all walks of life. When, however, we discover eyes of such formation that vision is affected, or peculiar hands not adapted to the use of ordinary tools, we are more disturbed.

Color blindness, especially in the common type, the inability to distinguish red and green, is in some professions a serious matter. Color-blind men are much more common than color-blind women. The children of a color-blind man, married to a normal woman, are normal, but if the girls of this generation marry, half of their sons will be color blind. A color-blind woman is found only when a color-blind man marries a woman whose father was color blind. If it be true that man is color blind when simplex, while the woman only when she is duplex, we should expect all the sons of a color-blind woman to have the trait. To this no exception is known. Bateson was able to find seventeen such cases, and all the sons were color blind.

We have all seen human albinos who are characterized by an absence of pigment cells so that the skin looks chalky white while the eyes are red, due to the presence of blood. Their vision is usually very poor. This appears to be a recessive condition. On the other hand, the affliction known as hypotrichosis (hairlessness accompanied by loss of teeth), appears to be a dominant.

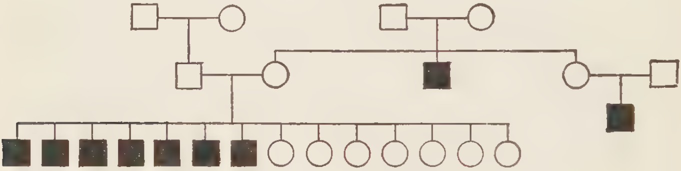

FIG. 20.—THE INHERITANCE OF HEMOPHILIA

Even more serious is the sex-linked trait known as bleeding (hæmophilia). The smallest cut is likely to be dangerous to one having the trouble, as the clot does not coagulate. In the family charted above [3] all the sons died in this fashion. The daughters do not have the trait. They will, however, transmit it to their sons but not to their daughters unless they chance to marry men who are also carriers.

There is considerable variation in the shape of the human hand. Most of these forms have little significance but some of them are important as when the fingers all coalesce into a hook. The common variants are of three types: (1) Polydactylic, with an extra finger (extra toes are also common); (2) brachydactylic, with short, stumpy hands and fingers; and (3) syndactylic, with more or less of a web between the fingers. These conditions are said to be dominant and to be found in given families for generations. The first type is shown in the following family chart.[4]

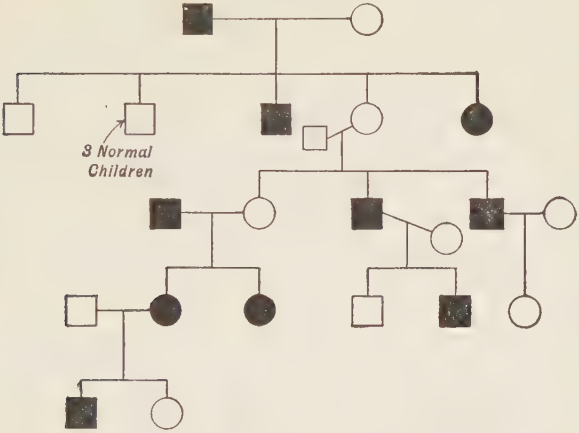

FIG. 21. THE INHERITANCE OF POLYDACTYLISM

Dwarfs are not numerous, and yet are found in all parts of the world. They are ordinarily of low mental caliber, and are unfitted for common pursuits. They are of two general

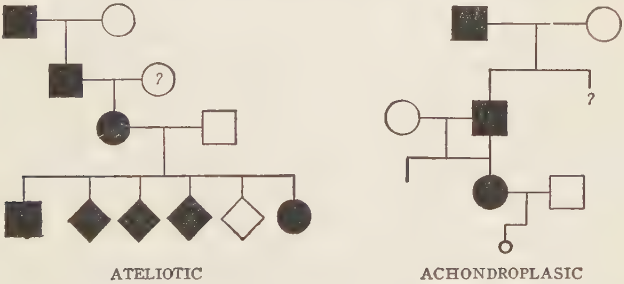

FIG. 22. THE INHERITANCE OF DWARFISM

types. The achondroplasic type presents a grotesque appearance with large head and stumpy limbs. This condition seems to be dominant over the normal. The ateliotic dwarfs are diminutive specimens of ordinary proportions, and the condition is recessive. Both conditions are heritable, as the diagrams in Figure 22[5] show, though the chart of the ateliotic type is incomplete and does not make clear its recessive character.

Blindness of young children is usually caused by disease and in adults is generally the result of accident. Most of the blind are adults. This indicates that heredity has little part in its production. I am unable to find any case of a family record. Deafness, however, is often inherited. This is shown by the census of 1900 where 4.5 per cent of the deaf were said to be the children of cousin marriages and 32 per cent of them had deaf relatives. Some deafness is the result of disease and accident, to be sure, but such deafness offers no danger to the race stock. No one can view the condition as anything but a handicap. Yet we are bringing young deaf boys and girls together in the special schools just at the time when their thoughts begin to turn to marriage and there is real danger of the formation of a deaf strain unless care be taken. It has long been thought that deafness was more common in certain families than others and many charts such as those above[6] have been drawn. It will be noted that the condition is recessive.

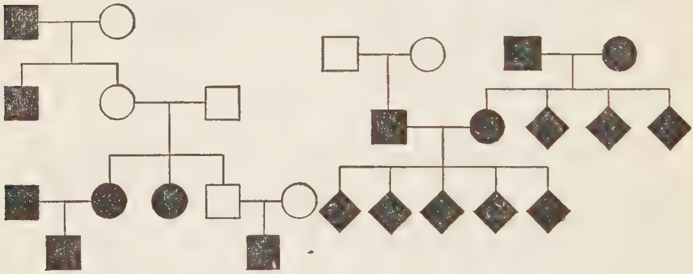

FIG. 23. THE INHERITANCE OF DEAF-MUTISM

Guyer gives a rather long list of other afflictions which behave as recessives.[7] Until recently we have assumed that all these were rather isolated cases. As more family records are compiled we find that wherever there have been settlements of afflicted persons in remote communities with considerable intermarriage defective strains have arisen. Thus, Martha's Vineyard was the old home of a line of deaf-mutes who have wandered over the country. A colony of bleeders originally developing in Sullivan County, Pennsylvania, has found new settlements in Minnesota, South Dakota and California. Long Island and Fairfield County, Connecticut, were the original seats of much of Huntington's chorea. Heredity has played a larger part than has been realized.

INHERITANCE OF MENTAL AND NERVOUS INFERIORITY

Serious as many of these structural defects of the limbs or sense organs have been, they are small in comparison with abnormal nervous or mental conditions. We may omit from discussion all the minor variations, such as the inability to distinguish tunes, which limit the enjoyment of the individual but which seldom handicap him in getting a living. There are, however, three large classes of people, so subnormal or abnormal mentally as to be seriously incapacitated if not wholly unfit for the ordinary duties of life. These are the feeble-minded, the insane, the epileptic.

The Feeble-Minded

In America this term has come to include all those who are mentally subnormal. In England it refers to the higher group of the subnormal only. Not infrequently among students the term *ament* (mindless) is employed. The feeble-minded are generally divided into three groups, idiots, imbeciles, and morons.

Tredgold defines amentia as "a state of restricted potentiality for, or arrest of, cerebral development, in consequence of which the person affected is incapable at maturity of so adapting himself to his environment or to the requirements of the community as to maintain existence independently of supervision or external support." [8] This definition illustrates the difficulty of drawing a sharp line between the subnormal and the normal. There is no more danger of mistaking the idiot for a normal person than of mistaking a baby for an adult. The trouble comes at the upper limit. We can tell whether a flower is red or blue. We can agree as to what constitutes a tall man though we arbitrarily separate the short from the tall. But we cannot measure and classify the brains of living persons and are, thus, forced to judge them by what they can do. According to Goddard, the feeble-minded can do the following things:

The idiot, regardless of age, never shows the mental capacity of a child over two. The lowest grade lacks the fundamental organic instincts, such as hunger and thirst; it has no power of attention; it cannot be taught. The higher class feels hunger and thirst and may be taught personal cleanliness to some extent. For practical purposes neither class can talk, though the higher idiots may show considerable verbal memory and repeat, parrotlike, words or phrases.

The imbeciles have mental ages ranging between those of normal children of two and eight. They can all learn to guard against ordinary physical dangers. The lowest group can do no useful work. The middle group can do simple work if supervised. The highest group can wash and dress under supervision. They can do simple tasks if explicit directions are given. Most imbeciles learn their own names; can recognize, but not describe, simple objects; may learn to read and spell words of one syllable.

Low-grade morons can run errands; do light work; take care of rooms, etc., if conditions are simple. The middle grade can do ordinary institution tasks. The high grade can do fairly complicated tasks with little supervision. They can run simple machinery; can care for animals. Many have served as soldiers and sailors, and as common laborers. They cannot plan. Mentally they shade into the normal.

Of these grades the morons are by far the most numerous. Tredgold states that in England out of each hundred, there are 6 idiots, 18 imbeciles, 66 morons, the males slightly outnumbering the females. Naturally enough the idiots and imbeciles have been long recognized as distinct from the normal. Many of the higher morons still pass as normal though often described as "off," "queer," or "stupid." This makes it difficult to get an accurate idea of the total number of the feeble-minded in any country. There are about 40,000 in the institutions of the United States but the best estimate of the total puts it as not far short of 300,000. In as much as feeble-mindedness often acts as a recessive there must be many million potential parents of such children. East and Punnett have estimated these as not less than 7,000,000 with a possible reproduction of 100,000 afflicted children annually. It has been stated that out of every thousand Americans drafted for the last war, 6 were feeble-minded.[9] In England it was estimated in 1906 that 4.03 of each thousand of the general population were aments. Every careful study, no matter where made, shows more than expected. In any case, the total is so great as to create a serious burden, both financial and social.

The popular explanation of the cause of feeble-mindedness has always been in terms of accident or brain fever in early childhood; the use of instruments in delivery; or some occult prenatal influence. The difficulty with such explanations is that a considerable time elapses ere the child's condition is realized. Then the parents, reviewing its history, can always discover some untoward experience. The explanation proves too much. Every child has such experiences; yet few become defective. As our knowledge grows, heredity stands out as an important cause. As Tredgold says: "What I wish to point out, however, is that mental defect is but rarely caused by injurious external factors acting alone, and that in an overwhelming proportion of cases the cause lies in the condition of the germ plasm."[10] He attributes about 80 per cent to heredity.

It seems clear that the feeble-minded taken as a whole include cases of various sorts, due, very possibly, to widely different causes. About one-half of the idiots appear in normal families in which we find no history of other defectives. One distinct type marked by features which has led to their being called Mongolians appear in many ways like the runts in litters of pigs. Often they come from families otherwise normal. They seem to be cases of arrested development, as if nature could not finish its task. They are very uniform as to mental age (seven) and die on the average at fourteen, seldom reaching the age of thirty, though Tredgold reports one who lived to be fifty-seven. The age at death of all the feeble-minded is low, though the life span seems to increase in institutions. In 2,801 cases in our institutions the age at death was 20.3 for idiots; 22.9 for imbeciles and 28.5 for morons. The crude death rate in England is about 20 but in institutions for aments it is over 30. Some of the feeble-minded appear to lack certain of the internal glands, a condition which may be hereditary. Tredgold[11] states that the thymus gland was lacking in 74 per cent of 292 cases examined. Years ago David Starr Jordan described the cretins of Europe and showed how the condition had been remedied by doses of thyroid glands.

Granted the rôle of disease or accident in many cases, as Tredgold says: "A close examination of the brothers and sisters of the affected individual will usually reveal some indications of mental abnormality."[12] He cites an investigation by N. E. Sayer which compared the family history of normal and defective children.

The discovery in the school at Vineland, New Jersey, of related children led to a very complete investigation of the

FAMILY HISTORY PER 100 CHILDREN EXAMINED[13]

Defect	100 Normal	100 Defective
Insanity	7	31
Epilepsy	6	11
Mental defect	2	34

family history of the inmates which revealed an altogether unsuspected amount of feeble-mindedness and gave a great impetus to similar studies elsewhere.

A study of the three following charts will help make clear the situation. The cases are chosen practically at random.

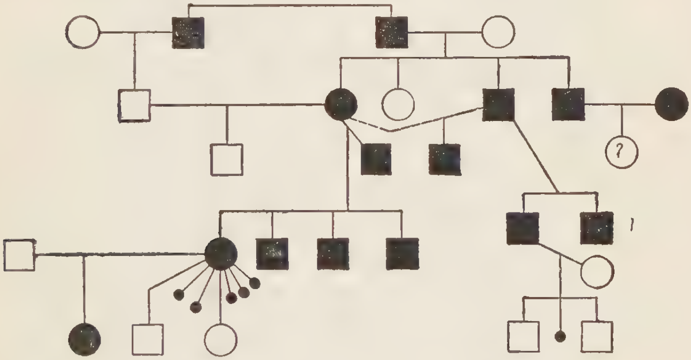

FIG. 24. THE INHERITANCE OF FEEBLE-MINDEDNESS[14]

In the first we have the intermarriage of related lines which carry the common characteristics of illegitimacy, incest, high infantile death rate and a large percentage of feeble-mindedness. In the second we see again the results of the marriage of two affected individuals and also the effects of crossing a normal stock with an affected stock even though the member of the latter be normal. In the third we have another illustration wherein the father of normal descent had normal

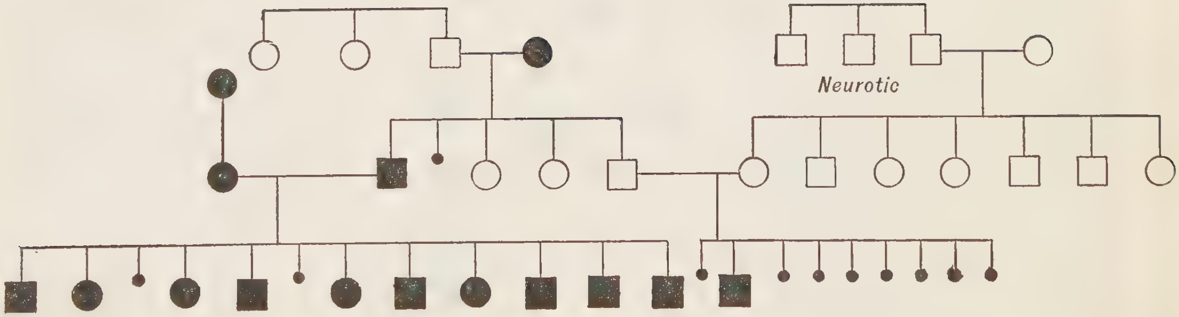

FIG. 25. THE INHERITANCE OF FEEBLE-MINDEDNESS[15]

children only by his first wife; while a later marriage with a feeble-minded woman produced at least three feeble-minded children.

When one studies such charts he can hardly fail to conclude that the feeble-minded represent, in great part at least, a defective strain of mankind which may reproduce itself under favorable conditions just as does any race of animals. It is admitted that it is difficult to get accurate information about most individuals of earlier generations and that over-zealous investigators may have exaggerated at times. Yet the fact that, in so far as we know, two feeble-minded parents never have normal children lends much weight to other evidence. Goddard has cited an apparent exception to the last statement wherein two normal children appeared in a family where the reputed parents were feeble-minded and the rest of the children were also—but the normal children were mulattoes while the alleged father was white. It is not unlikely that other seeming exceptions in feeble-minded families would be explained if we knew all the facts.

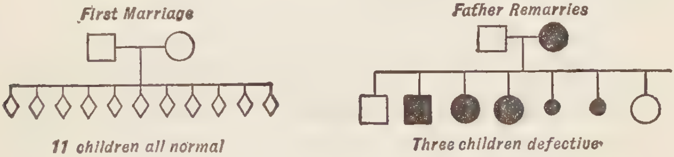

FIG. 26. CONTRAST IN CHILDREN OF TWO MARRIAGES

That which must be emphasized is that the feeble-minded are not backward normal children. They may learn a good deal; they may have rather marked sensory development as of sight or smell or sense of rhythm. but by no training can they be made normal. The lower idiots and imbeciles rarely can or do become parents. The morons may and do have children both in and out of wedlock. Thus the threat to the race stock does not come from the lower groups but from the upper. This danger is enhanced by the fact already noted that the condition often acts as a recessive and may appear therefore though the parents be normal themselves. It should be noted that the feeble-minded often become insane in later years.

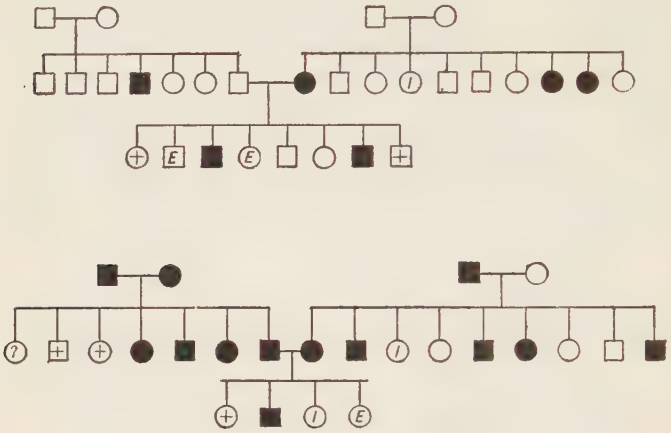

FIG. 27. NEUROTIC INHERITANCE[16]

Affected individuals shaded. *I*, insane; *E*, epileptic; +, dead, facts unknown.

Insanity

There are many forms of insanity and the word should be used in the plural perhaps rather than in the singular. The causes of some of these forms are known and it is sometimes said that 50 per cent of the cases could be prevented while not more than 25 per cent can be cured. Syphilis, alcohol, and worry are generally stated to be the three great causes. No brain or nervous system can stand up if attacked by syphilis so far as known. But it is not so easy to explain why alcohol and worry drive some insane and not others. It may be that there are human types, to be called neurotic, which are almost certain to break down if to the ordinary vicissitudes of life alcohol and worry be added. Judging by the results only we may classify the broken-down as feeble-minded, insane, or epileptic. We are far from understanding the problems involved. In the charts in Figure 27 such families are illustrated and it will be seen that though the parents appear normal in the first family, some of the children are affected.

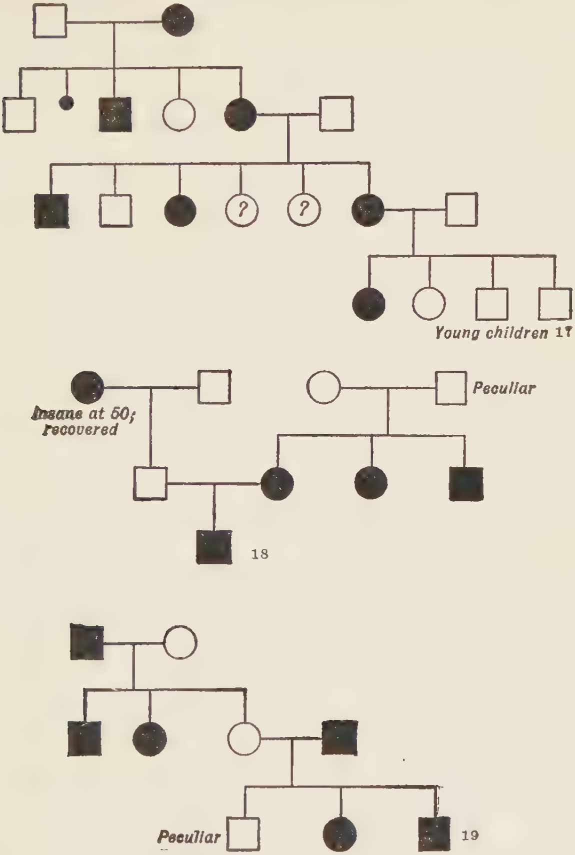

Fig. 28. Examples of the inheritance of insanity drawn from hospital experience

Of insanity, Myerson, out of a wealth of personal contact, has recently written:

> It seems probable that in all the periods of life there occur three main types of mental disease. The one is paranoiac type, a disease with hostility, suspicion, a deluded interpretation of the life around it and a gross, egoistic, over-valuation of the self. The second is a dementing disease, whose prototype is dementia præcox, but which occurs in modified forms in the involution and senile periods. The third is a disease marked mainly by a depressed mood, with lowered energy, absent interest and delusions of a depressive, apprehensive nature, occasionally with excitement and apprehension. The main disease of this type is manic depressive insanity but the involution and senile melancholia are related diseases, perhaps the same disease colored by the emotional and mental reactions of these periods of life.[20]

In his hospital experience Myerson has found many instances in which for successive generations members of given families have appeared in the institutions, as the charts in Figure 28 show.

Myerson has noted that "the psychoses of brothers and sisters tend on the whole to be alike, at least in their main characters." The types of mental diseases are more similar than are parents and descendants and yet he is unwilling to commit himself definitely as to the rôle of heredity. "We have no conclusive evidence at all that mental diseases are true hereditary characters in the strictest sense but that makes them of no less importance." [21]

Guyer seems a bit more inclined to stress heredity. He cites the case illustrated in Figure 29.

> Where more than one case of insanity occurs in a given family or stock it is presumptive evidence that a hereditary defect is at the bottom of it. As Dr. Wilmarth says, "mental accident may occur in any family, but it is rarely a second case occurs unless there is a tendency to nerve degeneracy." For example, of 818 insane in the Wisconsin State Hospital for the Insane during the biennium 1909-1910, 187 or practically one-

fourth, were positively known to have insane relatives. Of these 24 had insane fathers, 31 insane mothers, 30 insane brothers, 23 insane sisters, 25 insane uncles, 21 insane aunts, and 21 insane cousins. Where definite information could be secured it was found that of the 5,700 admissions of insane patients to the New York State Hospitals during the year ending September 30, 1911, 27.7 per cent of the cases showed a history of insanity in the family and an additional 22.9 per cent showed a history of alcoholism, nervous diseases, and the like.[22]

The Michigan Commission reported that 65.4 per cent of 4,917 insane in the state showed tainted ancestry.

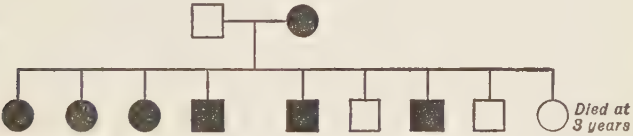

FIG. 29. GUYER'S CASE OF THE INHERITANCE OF INSANITY [23]

The total number of the insane in the country is probably somewhat less than that of the feeble-minded but the percentage in institutions is considerably larger, in part because most of the insane are adults. The number in the United States in institutions was about 287,500 in 1923 with 23,000 outside but under parole. The number outside not under supervision is a matter of guess. Tredgold says that there are about 36 insane in each one thousand of the population in England.

For many years there has been an apparent increase of the insane and this was true even of the Negroes after the Civil War. Just how this should be explained is much debated. Guyer says:

> The rate per 100,000 of population of patients with mental disease under institutional treatment increased from 118.2 in 1890 to 220.1 in 1920. In New York State in 1925 the rate of admissions per 100,000 of population was 416.7 Such figures of

course do not indicate a correspondingly rapid increase in insanity but rather the greater accuracy of recent enumerations, the growing practice of sending the insane to hospitals, and to some extent, reduction in their death-rate. Whether or not mental disorders are increasing in greater proportion than general population we have little reliable data from which to form an opinion. Regarding insanities we are almost wholly in the dark; many alienists believe that there has been an actual relative increase in recent years.[24]

Epilepsy

Epilepsy is a condition more baffling, if possible, than either of the two just discussed. In fact, we know nothing as to its cause. It seems to have a very real relation both to feeble-mindedness and insanity. Tredgold states that epilepsy appears in about 56 per cent of the simple idiots. He says that the "advent of puberty often ushers in a marked alteration of character and behaviour."[25] They become unreliable and destructive. Comparatively few epileptics ever recover. At the Craig Colony from 1896 to 1918 only 62 out of 4,077 patients were discharged as cured. In 1923 there were some 23,760 inmates in our institutions but there must be between 200,000 and 300,000 in the country.

Heredity seems to play a part in epilepsy and the English authorities appear to believe that about 35 per cent of the severe cases are inherited.

> In a paper by Weeks (*The Inheritance of Epilepsy*) . . . is recorded among others a study of 27 fraternities in which both parents were either epileptic or feeble-minded. Of the 28 progeny, 18 lived long enough to reveal their mental state. Of these 3 were feeble-minded, epileptic and 8, from parents who developed epilepsy late in life, were what Dr. Weeks terms "tainted." In 15 fraternities in which one parent was epileptic and the other feeble-minded he found there had been 81 conceptions. Of these 7 were too young to classify and 19 had died before fourteen years of age. Of the remaining 55, 28 were epileptic, 26 feeble-minded, and 1 insane. Again, in 9

families in which the parents were both feeble-minded, of the 38 surviving offspring who were old enough to classify, 7 were epileptic, 29 feeble-minded and 2 drunkards. In 5 families where one parent was insane and the other epileptic or feeble-minded, 5 children died before the age of fourteen, the condition of 2 was unknown, 2 were epileptic, 4 feeble-minded, 1 insane, 8 tainted, and 7 seemingly normal. Regarding the latter Dr. Weeks says they came from two families where in the one case the father's insanity seemed to be traumatic and in the other alcoholic.

In a study of 609 case histories of epilepsy by Olive Cushing Smith 336 showed a neuropathic family history, the family histories of 225 were negative (including organic nervous conditions), while those of 18 were unknown. In epilepsy the factor that is most universally present is an inheritable constitutional "peculiarity" of some kind. Such factors as diet, alcohol, injuries or focal infections are probably causative only in a secondary sense in that they operate on a nervous mechanism that is already inherently unstable.[26]

The discussion of the care and treatment of persons belonging in these three great groups has no place here. In many ways the most difficult social problem lies in the revelation that there are many thousands of potential parents of such defectives who themselves are normal in so far as we can see. Fortunately, good qualities are as heritable as bad, so let us turn to them.

Inheritance of Mental Superiority

Intelligence tests have become very common in recent years. Nevertheless it should not be forgotten that they are far from perfect and the one defect common to all is that in part they are information tests. Yet they have proved valuable and we may expect improvement as time passes. When such tests are carefully applied to a large and unselected group of children, or adults for that matter, we find that the children separate into smaller groups following the "normal curve" of distribution. The following figure[27] shows the results of such a test. The largest central group consists of normal or average children. Those whose mental capacity is lower fall in the spaces to the left while the superior children are shown to the right.

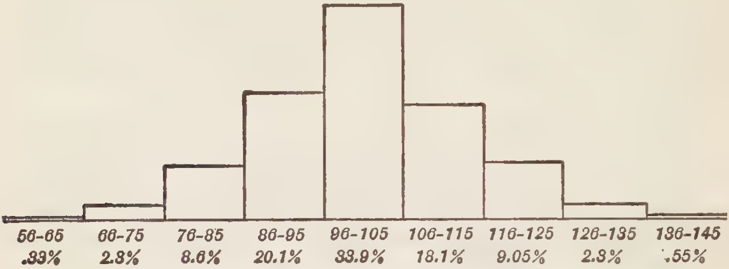

FIG. 30. THE DISTRIBUTION OF INTELLIGENCE [27]

The I. Q.'s of 905 unselected children, 5-14 years of age.

> Since the frequency of the various grades of intelligence decreases *gradually* and at no point abruptly on each side of the median, it is evident there is no definite dividing line between normality and feeble-mindedness or between normality and genius. Psychologically, the mentally defective child does not belong to a distinct type, nor does the genius. . . . The common opinion that extreme deviations below the median are vastly more frequent than extreme deviations above the median seems to have no foundation in fact. Among unselected school children, at least, for every child of any given degree of deficiency, there is another child as far above the average as the former is below.

Granted that there are as many above as below the average it needs no argument to show that the former are in position to make greater contributions to social welfare provided their powers are properly directed. It is equally obvious that they may do greater harm if they abuse their powers. This question does not now concern us. There has been, is, and will be, much discussion, often futile, as to the relative rôles of heredity and environment in the production of genius.

The genius is affected by his environment just as clearly as is the idiot. Our present task is to state the facts.

Environment and Achievement

Terman, from whom we have just quoted, has made a study of a thousand California children who had been picked out by their teachers as superior. On the intelligence scale all these rated as 140 or over, some as high as 190. That they came from families fortunately situated is revealed by the statement that the average family income was $3,300 a year.[28]

Occupation Group of Father	Proportion among Fathers of Gifted Children	Proportion Population of Los Angeles and San Francisco 1910 Census	Per Cent of Quota among Fathers of Gifted Children
Professional	29.1	2.9	1,003
Public service	4.5	3.3	137
Commercial	46.2	36.1	128
Industrial	20.2	57.7	35

It will be seen that the professional group furnished 1,003 per cent, or ten times its quota; the public service group 1.37 times its quota; the commercial group 1.28 times its quota; and the industrial group, which constitutes nearly 60 per

PERCENTAGE OF SCHOOL CHILDREN RANKING ABOVE MEDIAN OF ENTIRE GROUP[29]

GROUP	OCCUPATION OF FATHERS			
	Professionals	Executives	Artisans	Laborers
In highest 10 per cent..	41	10	8	6
In lowest 10 per cent..	1	2	12	17

cent of the population of these cities, 0.35, or one-third of its share of genius.

Pressey and Ralston obtained very similar results in a middle-western city.

As a matter of fact, all studies have indicated a close correlation between achievement and the social position of the families from which people come. Galton found that not more than one person in four thousand of the general population became eminent but that one of every eight sons of English judges was distinguished. Havelock Ellis in his *Study of British Genius,* 1904, assigned some 60 per cent of distinguished men to the professional and upper classes, 18 per cent to the commercial classes, 9 per cent to craftsmen, 6 per cent to yeomen and farmers, 3 per cent to officials and clerks and 2 per cent to laborers. Cattell in America found that the fathers of 885 leading scientific men had been engaged as follows:

Occupation of Father	Per Cent	Share in General Population
Professions	43.1	3.0
Agriculture	21.2	41.1
Manufacturing and trade.....	35.7	34.1

Woods and Ireland studied the records in the *English Dictionary of National Biography,* which included 30,000 distinguished persons of England and covered a period of a thousand years. It was found that 88.7 per cent came from the upper classes and only a little over 11 per cent from the lower. Later Ireland studied the records of those born between 1700 and 1800, 120 in all, and found that only 27 (22.5 per cent) came from the artisan, craftsmen and unskilled labor groups. Since 1825 only 6 (5.3 per cent) of 112 have come from the same groups.[30]

In as much as there is no dispute about the facts, we may grant the rôle of heredity in producing ability and accept the conclusions of Karl Pearson after a study of some 4,000 English school children.

> We are forced, I think literally forced, to the general conclusion that the physical and psychical characters in man are inherited in the same manner, and with the same intensity. The average home environment, the average parental instinct is in itself a part of the heritage of the stock and not an extraneous and additional factor emphasizing the resemblance between children of the same home. . . .
>
> Geniality and probity and ability may be fostered by the home environment and by provision of good schools and well-equipped institutions for research, but their origin, like health and muscle, is deeper than these things. They are bred and not created. That good stock breeds good stock is the commonplace of every farmer; that the strong man and woman have healthy children is widely recognized too, but we have left the moral and mental faculties as qualities for which we can provide amply by home environment and good education. . . .
>
> It is the stock itself which makes its home environment, the education is of small service, unless it be applied to an intelligent race of men.[31]

Specific and General Ability

One big question remains unanswered and unanswerable at present. Is superior ability general or limited to specific fields? It is not easy to find satisfactory evidence. The superior lawyer often succeeds later in life as a business executive. The college president seems qualified to lead a union of beggars. Provided no great technical knowledge is required the shift from one profession to another with equivalent success appears possible. The mature lawyer would find it almost impossible to become an equally successful surgeon. The musician may become a president but few presidents could qualify as musicians. High achievement in many callings requires long and arduous preparations. However, when one brother becomes a teacher, the second a lawyer, the third a doctor, is there any reason to question corresponding success had they shifted their choices at the beginning? This is equivalent to saying that we know little of specific ability so that the choice of careers is largely determined by early ideals and opportunities for preparation. Here is the crux of the whole matter. Men who achieve great things come from homes of great opportunities. Who is to determine whether the innate endowment or the opportunities have most to do with later achievement?

Apparently the clearest case of definite physical equipment for a career is in music. Possibly this is true of other artistic careers also, for artists have come from families of artists or craftsmen often enough to suggest a correlation, but musical talent appears so often in families that some definite nerve or brain structure seems evident. The most famous musical family of modern times started about 1550 with Weit Bach, a German baker, who found relaxation in music. His two sons started the line of musicians bearing the name of Bach which lasted unbroken for nearly two centuries. They were all organists or church singers. In no other family known to us have so many musical geniuses appeared, twenty-nine in all. Mozart, Beethoven and Amati were members of musical families. Thorwaldsen, Van Dyck, Murillo, and Titian came from families of artists. Yet, as often as not, when the son of an eminent man attains distinction, it is in some other field.

Genius and Eminence

Some years ago F. A. Woods sought to surmount the difficulty of securing accurate information about men and women of earlier generations by studying the royal houses of Europe. He classified the men according to ability into ten classes, the lowest being number one, and found that of every hundred the number in the different classes was as shown in the table following:

HEREDITY IN ROYALTY [32]

Class	Cases	Per Cent
1	7	0.17
2	21	5.3
3	41	10.4
4	49	12.4
5	71	18.0
6	70	18.0
7	68	17.2
8	43	10.9
9	18	4.6
10	7	0.17
TOTAL....	395	

> If we compare the eight hundred odd persons who form the main body of this study with the world in general, we cannot but be struck with the relatively large number of exceptional geniuses who have from time to time appeared in their genealogical charts and have taken their places as actual and undisputed leaders in many of the greatest movements in European history. Among the men alone there are 25 in grade 9 and 10. These are the bearers of the names of unquestioned distinction, names of geniuses who stand without superiors in the practical domains of war and government. Where else could we take eight hundred interrelated names at random and find twenty-five world geniuses?
>
> There is no doubt but that modern royalty as a whole has been decidedly superior to the average European in capacity; and we may say without danger of refutation, that the royal breed considered as a unit, is superior to any other one family, be it that of noble or commoner.[33]

To this last claim many will take exception. Compare the two following charts.

Elsewhere Woods has shown that eminent persons have a large number of eminent relatives by comparing the forty-seven elected to the Hall of Fame in New York City with a list of 3,500 names taken from two standard biographies.

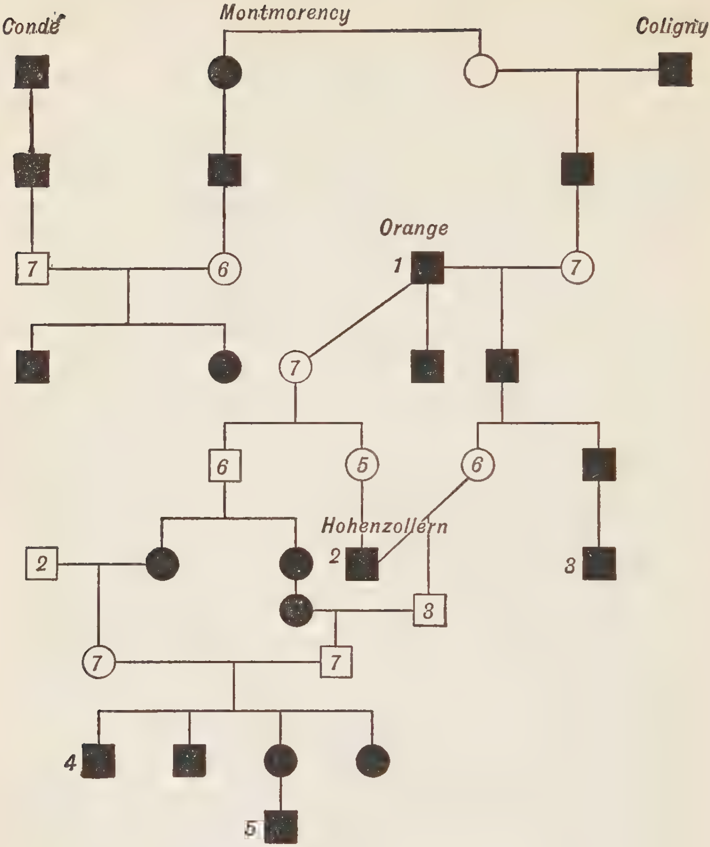

FIG. 31. THE INHERITANCE OF GREAT ABILITY [84]

Shaded figures in 3 highest grades. Numbers within symbols indicate grade. Numbers outside symbols indicate the following individuals: 1, William the Silent; 2, The Great Elector; 3, William III, England; 4, Frederick the Great; 5. Gustavus III, Sweden.

Now the chances that an ordinary mortal—any man taken at random—will be as closely related (as close as a grandparent or grandson) to any person in this second group (the 3,500 group) is about one in five hundred to perhaps one in a thousand. In contrast to this, fully one-half of those in the Hall of Fame are closely related to some one in the second group, and, if all their distinguished relatives are added up, they average more than one apiece. In other words, the amount of distinguished relationship which the Hall of Fame gives is about a thousand times the random expectation.[36]

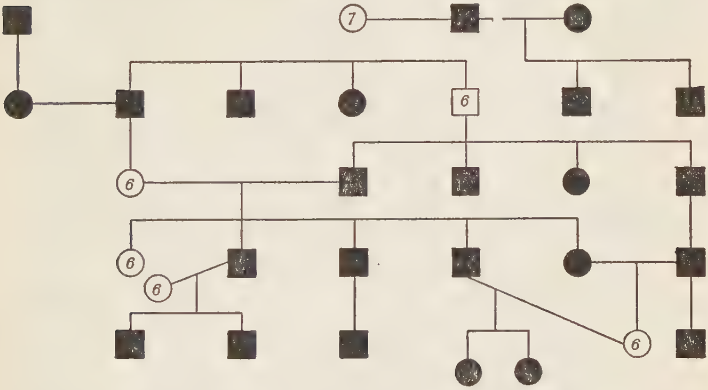

FIG. 32. THE INHERITANCE OF LOW ABILITY: THE BOURBONS IN SPAIN AFTER 1700[35]

Shaded figures under Grade 6. Numbers indicate grade.

There is a real danger underlying most of current discussion about genius. The dominant group likes to boast of its ancestors and to assume that equal ability is not found in other groups. The less successful groups always explain their position as due to lack of opportunity. The correlation between existing social classes and ability remains to be proved. The development of great men in countries like America and Australia, the rise of Japan in the last century, the promise of China for this, can hardly be accounted for solely in terms of heredity. Great ability must have great opportunity, and opportunity and training are not always at hand. Moreover we are comparing the reputations of earlier men, not their capacities. There may have been many men of even greater ability than those we know. The ablest man does not always become president. The actual inventor may have his designs stolen. Society, then, should try to give every man a chance for development.

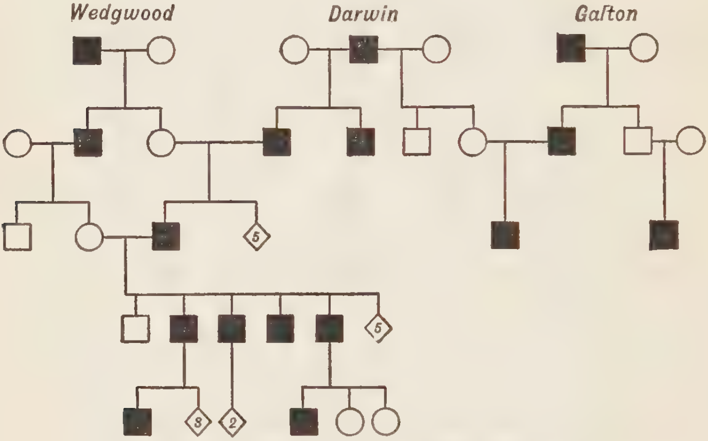

FIG. 33. THE INHERITANCE OF ABILITY IN THE WEDGWOOD, DARWIN, AND GALTON FAMILIES[37]

Shaded squares represent men of exceptional ability; figures in diamonds represent other children, sex not stated.

The trend of the whole investigation has been in the general direction of showing that great men have been produced by the coöperation of two causes, genius and opportunity, and neither alone can accomplish it. But genius is a constant factor, very abundant in every rank of life, while opportunity is a variable factor and chiefly artificial. As such it is something that can be supplied practically at will. The actual manufacture, therefore, of great men, of the agents of civilization, of the instruments of achievement, is not a utopian conception but a practical undertaking.[38]

So wrote Ward and as evidence he cited the studies of Odin which included 816 eminent men of letters of France. He found that only nine of every hundred came from poor families, although the latter constituted 97 per cent of the population. The nobility had furnished two hundred distinguished men to every one from the laboring classes. But, all these men save sixteen had received university educations and had exceptional opportunities as children. So Odin concludes: "We have thus arrived, by a series of careful approaches and eliminations, at the conclusion that the fecundity of the respective localities in remarkable men of letters rests essentially upon the educational resources that they place within the reach of their occupants." [39]

Whether actual genius be as common as Ward held or as rare as Galton and Woods thought, it is none too common and the ambition to achieve great things needs to be stimulated rather than repressed. Suppose, however, it be found as many have held that the superlatively endowed man was so one-sided as to approach the insane, what attitude should be taken? Men like Edison say that genius is "two per cent inspiration and 98 per cent perspiration." This means that great achievement means hard work in some given field and this may lead to one-sided development and interests. There is little evidence that most genius contains anything of abnormality. As Myerson wrote: "Among the 700 families of the insane of Taunton I found no case of 'genius' and few of high grade talent." [40]

EUGENICS

As a result of the discovery of the number of low-grade folks coupled with the revelations of the accomplishments of men and women of good stock, the eugenics movement has developed and gained considerable headway. It has two aspects, negative eugenics, the prevention of the reproduction of the unfit, and positive eugenics, the encouragement of the reproduction of the best. Stated thus every sensible person becomes at once an advocate, but great difficulties arise whenever we try to make concrete application of the idea.

Sterilization of the Unfit

Who are the "unfit" and by what measures is their reproduction to be stopped? Let us limit the discussion to biological unfitness. Take the feeble-minded as the best illustration. Every one agrees that they are undesirable either as children or as parents. It is patently absurd that the laws of most of our states do not forbid their marriage. But the lower grades are practically eliminated from the discussion for they seldom propagate. The higher grades care little for such prohibitions and will reproduce without reference to statutory requirements. We are driven then to advocate either their segregation, particularly of the women during childbearing years, or some surgical sterilization making parenthood impossible. The first policy will be immensely expensive. The second encounters great opposition because of the curious antagonism of some religious groups to any interference with reproduction and because of the fear that the great power with which some one would have to be invested might be abused. Oddly enough it is relatively easy to sterilize the male but the asexualization of the woman demands hospital conditions. As a punishment for certain crimes asexualization has been imposed (seldom carried out) in a few states.

Since 1907 when the first law was passed, some twenty-three states have enacted laws providing for sterilization and over 6,000 individuals had been treated up to 1925.[41] In California, between 1911 and 1927, some 3,951 insane persons in institutions and, up to June 1, 1926, 1,054 feeble-minded were asexualized. In most states and at most periods these laws have not been enforced. Regardless of their merits they are in advance of public sentiment. The present status of the problem is most unsatisfactory. Adequate provision has not been made for segregation and all our institutions are overcrowded, with thousands not admitted. The cost of adequate care may force a change in public opinion which scientific evidence cannot effect. The argument that asexualization will increase the amount of sexual immorality has little weight to those who know the feeble-minded. The great difficulty lies in the fact that the subnormal shade into the normal, while thousands of normal folks are potential parents of subnormal children, as has been shown. But it is from the upper groups that most of the offspring come. The situation is one that calls for caution and long consideration. Unfortunately we cannot carry on breeding experiments as we would with lower animals to discover the best solution. Let us read what two men of long experience have to say.

Tredgold writes:

> For my own part, I am convinced that the nation which wishes to escape degeneracy will sooner or later have to give serious consideration to the matter of the innate constitution of its citizens, and the manner in which that innate condition may be controlled by laws concerning marriage. Nevertheless, I do not think that any legislation on these lines is possible at present, for two reasons: Firstly, because the laws regarding hereditary transmission are not sufficiently known; and, secondly, because we have no data regarding the antecedents of the mass of the people.[42]

Myerson also pleads for further study:

> In other words, a study of those environmental forces which alter character and the general trends of the physical and psychical life of individuals must be linked up to a study of those environmental forces which alter these sets of qualities in a family group or the race. That long and arduous studies await us before we can even prepare to understand the problem of family mental disease needs no argument, but that is only an-

other reason why they must be made. And especially must they be made before we leap into Legislatures with demands that this or that measure be carried out, before we call for the wholesale sterilization of the feeble-minded, the insane, the epileptic, and the criminal as blithely as if we knew all about the inheritance of mental disease when indeed we know remarkably little. We have a right, I think, to pass laws that no one shall conceal the fact of mental disease when entering upon marriage and that the concealment of such disease shall be a cause for annulment, whether or not the individual was insane at the time of marriage. We have a right to ask for the sterilization of those types of feeble-mindedness which we know to run in families. Wherever mental disease exists in a family group for more than one generation, it would be wise for society to sterilize those of the second generation who go to institutions. I do not believe we can ask for much more than this in the present state of our knowledge and we cannot afford to be unduly dogmatic.[43]

Breeding from the Best Strains

Positive eugenics is the attempt to improve the quality of race stock by encouraging the reproduction of the best strains. In the main it is now an ideal accompanied by a duty rather than an immediate program of social reform.

As a matter of fact, intelligent men and women have long given some consideration to eugenics. On the negative side they have often refused matrimony if they knew of some defect in the family line, or have sought mates coming from other strains. Health, strength and beauty—all indications of fitness—have often turned the scales. Few, however, have consciously thought to produce children with any given endowments. No doubt people can be trained to look on this or that type of suitor as undesirable. This now happens where race prejudice separates groups. The fundamental difficulty is that financial, social, political, religious considerations, rather than physical, loom so large in human choices.

Perchance this is not an unmixed evil. We breed plants or animals for specific purposes and they become more valuable as they are specialized. If society is to be controlled by some autocrat, each citizen playing a rôle in large measure determined by the autocrat who decides whether a man shall be senator or woodchopper, or rather, decides how many senators or woodchoppers are needed, then specific and heritable qualities might be emphasized. But to most thoughtful men of to-day a beehive efficiency purchased at the cost of fixity of status does not seem a high ideal for society.

We are what we are, therefore, because of what our ancestors were, not because of what they did. Heredity sets the limits. Some day with greater knowledge we shall do more to check the unfit. Let us hope that we shall also create social ideals which will lead to more complete realization of innate possibilities unhampered by artificial and unwise restrictions.

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CHAPTER XIII

SEX AND SOCIETY

> Only the chemist can tell, and not always the chemist,
> What will result from compounding
> Fluids or solids.
> And who can tell
> How men and women will interact
> On each other, or what children will result?
> There were Benjamin Pantier and his wife,
> Good in themselves, but evil towards each other;
> He oxygen, she hydrogen,
> Their son a devastating fire.
>
> —EDGAR LEE MASTERS

Sex in Lower Organisms

The first hint of sex in the organic world appears to be in the close association and subsequent separation of the chromosomes of unicellular organisms. Sometimes this is accompanied by an exchange of material. Some of these unicellular forms occasionally unite, trade material, separate again. Rejuvenation appears to result. As yet there is no sex. A step higher on the ladder of life and we come to the protozoan Volvox where vast numbers of cells unite in colonies. Some of these cells grow to great size and break away from the old associates to form new colonies. In some cases certain cells divide and produce cells equipped with whip-lash tails which then conjugate with the other type of cells and thus start a new colony. The egg cells are large, the sperm cells minute. "One volvox, therefore, is either unisexual or hermaphroditic—it is neither male nor female.

As the ova themselves can form complete colonies without the need of fertilization, the volvox is also *parthenogenetic* (virgin reproduction). In short, volvox, as Geddes says, is an 'epitome of the evolution of sex'."[1]

Nature appears to be experimenting. Plant lice have a generation in which both sexes are present, followed by several generations in which there are no males. The hickory phylloxera has a curious history. In the spring females only appear and lay their eggs in a leaf ball. These eggs may be either large or small but from the large eggs females only are hatched; from the small eggs, males only. After fertilization these females lay the large eggs which last over the winter to renew the cycle the next spring.

In the plant world many species bear perfect flowers while others have only male or female flowers. There seems to be no other difference in these latter species. The only possible explanation is that this is a device to secure cross-fertilization which involves inheritance from two lines.

Some lowly animal forms like snails, leeches and earthworms are hermaphroditic, *i.e.*, producing both male and female cells, and this condition is believed to occur even in birds and mammals.

Sex Differentiation

The first great difference between the sexes, then, lies in the fact that they arise from fertilized eggs with a certain chromosome content and that later they produce only ova or sperms as the case may be. The sperms are among the smallest of cells while the ova may be a hundred thousand times larger.

The sex organs constitute the second set of differences. Closely associated with these, though the causal connection is far from clear, are the differences in other organs of the body. The male spider is a pygmy in comparison with its mate. The plumage of the male bird contrasts with the more demure colors of the female. There is no uniformity in these differences. Externally the male and female kingfishers are almost identical, as are the rabbits. Yet in mammals these differences hark back to the very early fetal stages. Quite possibly they are produced by hormones secreted by certain glands of the body or by the influence of the germ cells themselves. This is an involved and difficult problem about which biologists are much perplexed.

Finally there may be differences in the emotions and intellect, either caused by or associated with some of the other differences just mentioned. These differences will show themselves in behavior rather than in structure.

The possible differences between the sexes, then, appear to be:

1. Germ cells
2. Sex organs
3. Endocrine glands
4. Other organs of the body
5. Emotional and intellectual equipment

The unfertilized eggs of the bee develop into drones, but the fertilized eggs produce the workers and queens. The difference between the two last appears to be a question of food only. This indicates that actual development depends on conditions. There is much reason to believe that even in man we have to do with an asexual body which develops male or female characteristic depending on the stimuli present. Sometimes in insects, and rarely in birds, individuals are found where one side of the body is of the female type, the other, of the male. A bullfinch has been found which had on one side of its breast the red feathers of the cock and on the other, the brown feathers of the hen, the two sharply separated. Castrated animals do not wholly lose earlier characters but do tend to approximate a halfway stage between the two sexes.

Relative Numbers of Males and Females

Accepting the idea that sex is determined by the presence or absence of certain genes in the germ cells, and recalling the fact that one sperm unites with one egg, we might anticipate that in all forms of life the numbers of the two sexes would be about equal. This is far from true. In some nematode worms there are over one hundred females to one male, though here the females are really hermaphrodites. Bees and wasps produce few males. Matings of guinea fowl and pheasants have produced 74 males to 13 females, and crosses between different species of the same genus have shown 72 males to 18 females. Hybrids often show an excess of males. Even in human beings there is no absolute equality.

About one hundred and five boys are born to every one hundred girls in modern society. Our figures are not wholly accurate for different countries; still they agree in the main: England, 103.6; France, 104.6; Germany, 105.2; Spain, 108.3; United States, 106. If stillborn infants are included the ratio is higher: Germany, 128.3; Italy, 131.1; and France, 142.4. If abortions are counted the difference appears to be still greater.[2] We do not know how to explain these returns though explanation is possible without surrendering the belief in sex determination by chromosomes.

Assuming the substantial accuracy of the figures just given, the death rate of males in fetal life is higher than that of the females. The same holds true in later life. In the first four months of pregnancy 180 males were lost to a hundred females, according to one student of the returns from Paris. Taking the last year reported in a recent study of infants during the first year of life, the number of boys dying to each hundred of girls was: England and Wales, 128; Sweden, 123.7; United States, 129.2; Australia, 131; New Zealand, 134.7; Baden, 138.1.

> All the facts point to the male as the frailer sex. From the earliest embryos in which distinctions of sex are readily traced, through the precarious period of infancy and even into advanced years, natural selection discriminates against the male. It is only in the child bearing period, and in some countries not even then, that the death rate of women is, on the average, higher than that of men. To a certain extent in adult life, and to a large extent in the periods of infancy and ante-natal development, the higher mortality of the male is doubtless an expression of his inherent inferiority in constitutional origin or vitality. In early infancy his vitality is relatively lower than that of the female and only gradually approaches it in later years. The causes of the greater difference in early infancy are internal and constitutional, and not external or adventitious. The external conditions are practically the same for both male and female infants in early infancy as they are also in prenatal life.
>
> If one goes over the 189 causes of death listed in the volumes of the United States Mortality Statistics, he cannot fail to be impressed with the relatively high male mortality in infancy from practically all causes. Even accidents are more fatal to males than to females. With the single striking exception of whooping cough and the somewhat doubtful exception of gonococcus infection, all of the causes of death which affect infancy take a relatively high toll of the male sex, and this discriminating death rate continues for most causes of death through several years of childhood. There can scarcely be any other explanation of this than that the male is handicapped by lessened degree of vitality that is directly or indirectly the result of his peculiar complex of hereditary factors.[3]

Without discussion of causes we may note that this inequality exists in all age periods and that it is not until the age of seventy is past that women outnumber men in the United States.

Sex Determination

The starting point of all differences between the sexes, is then in the original germ cells. These germ cells are increased by ordinary division like other cells. They also go through a maturing division in which the process is somewhat

NUMBERS OF MALES AND FEMALES IN THE NATIVE WHITE OF NATIVE PARENTAGE POPULATION OF THE UNITED STATES

AGE GROUP	CENSUS, 1910		CENSUS, 1920	
	Males	Females	Males	Females
Under 10	6,295,467	6,111,830	7,275,286	7,069,107
10-19	5,253,184	5,160,154	6,066,865	5,987,890
20-29	4,379,511	4,352,485	4,914,130	5,027,379
30-39	3,321,708	3,125,274	4,017,305	3,894,588
40-49	2,355,817	2,166,544	3,047,493	2,804,850
50-59	1,829,988	1,601,602	2,085,648	1,870,242
60-69	1,106,175	1,052,866	1,390,551	1,266,300
70-79	495,889	506,528	630,166	641,814
80-89	114,444	132,773	140,952	174,596
90-99	8,086	11,302	9,377	14,615
100 and over	180	259	614	385
Unknown	68,769	28,740	58,759	33,410
TOTAL	25,229,218	24,259,357	29,364,704	28,785,176

different in the two sexes. Ten years ago the chromosome count in the sperm was stated as forty-seven, in the ovum as forty-eight. It is now known that both have forty-eight but the sperm contains one of ordinary rod shape (now called *X*) while the second is spherical (called *Y*). In the reduction division in the female, twenty-four of these chromosomes are thrown out and the final ovum is larger in size but contains only twenty-four chromosomes, all of the *X* type. In the male after the reduction division all the sperms are functioning but one-half contain the *X* chromosome, one-half the *Y*. Depending on which of these unites with the ovum, a boy or girl develops. Since all the body cells result from these germ cells it follows that there is a certain difference in every cell of the body of the two sexes.

The process of making a man or a woman is well on its way at time of birth, yet it is far from complete. There is evidence that the hormones produced by the germ cells do

Sex Differences of Height and Weight in School Children

Age in Years		Height	Degree of Difference	Weight	Degree of Difference
8	Boys.......	124.07	+1.89	....	....
	Girls.......	122.18	....	....	....
9	Boys.......	128.00	— .62	....	....
	Girls.......	128.62	....	....	....
10	Boys.......	131.80	— .32	28.40	+ .27
	Girls.......	132.15	....	28.13	....
11	Boys.......	136.06	—1.64	30.77	—1.22
	Girls.......	137.70	....	31.98	....
12	Boys.......	142.10	—2.23	34.20	—1.52
	Girls.......	144.36	....	35.72	....
13	Boys.......	146.77	—4.53	38.25	—3.50
	Girls.......	151.30	....	41.75	....
14	Boys.......	153.14	—2.26	....	....
	Girls.......	155.40	....	....	....
15	Boys.......	158.70	+2.0	47.83	+ .33
	Girls.......	156.70	....	47.50	....

much to determine the later character of boys and girls. There is reason to believe that the endocrine glands are extremely important for the normal development of the individual. Whether there is any difference in the equipment of the two sexes as regards these glands is almost wholly unknown and it is a field monopolized by quacks rather than students.

Physical Differences between the Sexes

The infant begins to grow and the rate of growth varies with the sex. In England and America at least, "until the age of nine, boys are above girls in height and weight; at nine and ten are slightly under in height; at ten slightly under in weight; at eleven materially lower in height and weight; at fourteen boys are slightly heavier than girls; at fifteen taller than girls. In other words the pubertal acceleration of growth occurs about three years earlier in girls than boys." [4]

The preceding table shows the differences of height and weight of school children at Battle Creek, Michigan.[5]

The period of growth over, the most obvious physical differences between men and women are (1) relative size and strength, (2) proportions of the body, (3) distribution of hair on body, (4) voice.

In all races of men, man appears to average taller, larger and stronger than woman. These differences seem less marked in the more primitive groups and more marked among civilized peoples. This suggests that to some extent they depend on differences in daily life. Our college men are about 68 inches tall, college women 63. For this difference heredity is our only explanation. The striking superiority of college men in athletics is in part an index of activities, but only in part. Structural differences are involved.

The proportions of the body differ much as between the sexes. The arms and legs of the man are relatively longer than those of the woman. The thigh of the woman is much shorter and of larger girth and is set at a different angle. The most striking difference is in the shape of the pelvis, which in woman is large and broad thus making possible the bearing of children with the relatively large heads characteristic of infants. This is a distinctly human trait for it is found nowhere else in the animal kingdom. This pelvis affects woman's carriage of the body. Man's skull is heavier, with larger frontal sinuses and more pronounced ridges over the eyes and nose. An expert would rarely mistake a woman's skull for that of man.

There is no special difference in the hair of the head though woman at times seems to have more and to be less inclined to baldness. Man's beard is very characteristic, but this varies with the race and is never found on the woman though she often preserves the early coating of down—the lanugo.

The changes in the boy's voice at puberty is universally known. Due to the growth of the larynx, his voice becomes deeper and stronger.

There are other differences not always apparent. Possibly one of the most significant of these is in the blood. All the observers seem to agree that the blood of woman contains fewer red corpuscles and that its specific gravity is lower.

> In males the specific gravity is about 1,066 at birth, and falls during the subsequent two years, being about 1,050 in the third year; thence it rises till about seventeen years of age, when it is about 1,058. It remains at this height during middle life, and falls slightly in old age.
>
> In females the specific gravity, starting at about 1,066 at birth, falls in infancy, as in males, to about 1,049 in the third year. Thence it rises till the fourteenth year, when it is about 1,055.5. Between seventeen and forty-five years of age it is lower than at the age of fourteen, and is about three degrees lower than in men.
>
> It will be seen that it is at puberty that the sexual differences become marked. . . . In old women the specific gravity rises.

The pulse of woman beats about ten times a minute more than that of man.

The amount of carbon consumed in the male body rises at puberty to about double the amount consumed in that of the female. Women seem to need less air than men.[6]

There is a considerable body of evidence justifying the widespread belief that woman is essentialy anabolic, *i. e.*, tends to store up strength and energy; while man is katabolic, *i. e.*, tends to dissipate his energy. Woman is more likely to become fat. "Statistics show that woman is more susceptible to many diseases, but in less danger when attacked, because of her anabolic surplus and also that the greatest mortality in woman is during the period of reproduction, when the specific gravity of the blood is low and her anabolic surplus small."[7] The biologist would say that woman needs this reserve to meet the demands of childbearing—a burden utterly unknown to the male.

Ploss, after a long review of the evidence, comes to the conclusion that:

> The bodily needs of women are much less than those of men; they eat and drink less; they breathe less and withstand suffocation better, it is believed. All troubles, at least those which slowly develop and persist, all deprivations, they bear much better than men, in part at least, much better than one would expect considering their physical powers. They better withstand loss of blood and persistent pains. Even the greater sensitiveness of the nervous system, because of which many trifling disturbances cause lasting after effects, appears to favor the rapid and harmless dissipation of the upsetting experience. Thus they reach old age, often, under unfavorable circumstances though the cases of extreme old age reaching well into the second century are almost always men.[8]

Of the effects of industry on the two sexes a very competent English student says:

> In these days we find men and women of unequal powers of resistance crowded into factories and trying to keep pace with machinery. . . . Resistance to fatigue is not only a matter of health and physique but of sex as well. Woman is physiologically handicapped and therefore goes down more readily. . . . Data concerning some aspects of fatigue problems are unobtainable because, notwithstanding what has been said, there are many women who are not only physically equal to men, who work as hard and bear fatigue just as well as, if not better than, many men. This applies rather to the few than to most women. In cotton mills in Switzerland, where both sexes are employed, Schuler and Burckhard found the relative morbidity of men and women in the spinning department 100: 13. The duration of sickness is higher for women than men. Even where the morbidity tables of Insurance Societies show men to

be more frequently ill than women the duration of their sickness is shorter. Taking a Swiss Insurance Company, I find, "Among 100 insured men an average of 26.76 received sick relief but among women only 24.26. The men who received sick relief averaged 23.55 days of illness, the women averaged 32.36." The women showed a lower percentage of relief but a longer average duration of sickness, and as a result of these two circumstances the average morbidity of the women is higher than that of the men, 7.87 as against 6.30. In one of the German Insurance Societies for each 100 persons the men averaged 21.6 days lost through sickness and the women 24.4 days, while in an Austrian Society the men lost 16.5 days and the women 18.8. Generally speaking women lose more days from sickness than men; they are less able to bear the strain which modern industrial methods are imposing upon them.[9]

Special Functions of the Female

Girls, as already indicated, reach maturity somewhat sooner than boys. In the tropics the first menstruation usually occurs by the age of twelve; in colder countries at sixteen. Maturity not only brings to the girl a physiological phenomenon unknown to boys (menstruation), but it makes new and different demands on her metabolism. Just how significant menstruation itself is in the life of woman is a matter of dispute. Often it is a period of suffering and mental depression. There is a marked decrease of lime in the blood while certain poisons are found in the fluids of the body. So, too, the menopause often introduces troubles from which man seems free.

For some unknown reason, the thyroid gland which affects brain growth in both sexes is intimately related in woman to the reproductive organs. In as much as woman must bear the children it is evident that nature must provide the needed equipment. Possibly due to this need the brain of woman slackens growth by the age of fifteen and stops at eighteen while the brain of man grows till twenty-five or thirty. It may be that some of these physiological changes have profound effect on the emotional life. More than this it is unsafe to say in the light of present information though extravagant and often preposterous statements are very common.

Alleged Mental Inferiority of Women

Skulking behind most current discussions is a theory that woman is not as well endowed mentally as man. The evidence offered is far from conclusive. Structurally woman's brain is the same as man's. Since man is larger and heavier his brain weight seems likely to be greater. The results of seven students averaged together gives a brain weight of 1,376 grams to man, 1,237 grams to woman—a difference of 139 grams.[10] No one knows that this difference has any meaning, nor that total weight is important. Some low-grade men have had heavy brains, far above the average, and some very able men have had to get along with light brains. The attempt to correlate brain weight to body weight is unsatisfactory, for it gives an advantage to woman because man's body weight as compared to woman's is about 100 to 83; while that of the brain is 100 to 90.

In reality we must turn to achievement for our evidence, but achievement is conditioned upon so many things in addition to inherent capacity that the evidence is most unsatisfactory. Put the two sexes side by side in the same schools and no difference in their attainments is evident. Language is a great human achievement but woman seems not to be handicapped in its use. In fact, most of current argument that woman has not done this or that in history is equivalent to complaining that where sovereignty has been limited to men there were no female sovereigns. The division of labor, intellectual as well as physical, has debarred women from active competition with men in many intellectual fields. History, therefore, wholly fails to indicate what women might have done had conditions favored the attempt. The verdict of Thomas merits attention:

It must be confessed that the testimony of anthropologists on the difference of variability of men and women is to be accepted with great caution. As a class they have gone on the assumption that woman is an inferior creation and have almost totally neglected to distinguish between the congenital characters of women and those acquired as the result of a totally different relation to society on the part of women and men. They have also failed to appreciate the fact that differences from man are not necessarily points of inferiority, but adaptations to different and specialized modes of functioning. But, whatever the final interpretation of details, I think the evidence is sufficient to establish the following main propositions: Man consumes energy more rapidly; woman is more conservative of it. The structural variability of man is mainly towards motion; woman's variational tendency is not toward motion but toward reproduction. Man is fitted for feats of strength and bursts of energy; woman has more stability and endurance. While woman remains nearer to the infantile type, man approaches more to the senile. The extreme variational tendency of man expresses itself in a larger percentage of genius, insanity and idiocy; woman remains more nearly normal.[11]

In this hurried survey we have glanced at most of the real or alleged sex differences now known. It would seem that the differences are either those due to sex or to social arrangements. No one disputes the importance of sex and it is hard to overstate the rôle it has played in history. It is foolish to talk of the superiority or inferiority of either sex. We must not forget that each person has two parents and that his qualities depend as much on the contribution of the mother as on those of the father. The sire has as much to do with the quantity and quality of the milk given by the cow as does the dam. The chromosomes in each cell of the body come from both parents, not from one alone. There are more biological facts about sex which we do not understand at present. It is evident that many of the sex divisions of labor and customs have been based upon artificial or, at least, trivial differences.

Division of Labor between the Sexes

When one has read a considerable number of accounts of the social life of the various peoples of earth he realizes quickly that it is quite impossible to devise any one scheme to show the activities of men as compared to women. There is a shadowy line of separation due to the long pregnancy of the mother and the subsequent nursing of the baby—a process extending two or three years among primitive people. This makes it easier for the father to roam about and has been a factor at least in giving him chief responsibility for such activities as hunting. To him falls also the warfare, both offensive and defensive. As the home developed among sedentary peoples, household duties, the preparation of food, and oftentimes the making of clothing and such related tasks as the care of the garden have been allotted to woman, but the older men no longer active have shared these tasks. No one can state that the duties of woman have been easier, for to our modern eyes they often appear as even more onerous than those of man. On the other hand, it is foolish to say that man has deliberately and maliciously taken advantage of the situation to impose on woman. The truth appears to be that the division of labor between the sexes has come about as a practical adjustment to a given situation without any special theory involved. Once established, custom and emotion play their part and a philosophy develops to justify any given practice.

From the moment when the purely physical care of the infant changes into the education of its mind, the boy is trained to be a man, the girl, a woman. To most students it seems that Freud and his followers have grossly overemphasized the sexual but they are probably correct in asserting that our deepest instincts grow out of the most intimate associations of family life. The boy is taught to act as a boy, to play as a boy, to learn the ways of men. How different the training of the girl! Thus there comes to be not only a division more or less accidental of activities but a separation—deliberate and inculcated—of viewpoint and emotional reactions. Nothing is more condemned than the development of traits of the other sex. We want a woman to be womanly, a man, manly. Thus there comes to be a classification of virtues (and vices) almost in terms of sex. Beauty is feminine; bravery, masculine.

The difficulty with such a program lies in our desire to make it both universal and final. Everywhere circumstances arise which compel individuals to assume the responsibilities of the other sex, as during the late war. In such an emergency no one knows how far we may drift from old standards.

The Position of Women in Society

Much more serious, historically speaking, is the fact that such sex distinctions may come to be thought of as higher or lower. It is a curious paradox that Christianity which has always stressed the worth of the individual and which has especially emphasized the virtues which we of to-day would call feminine, started with a distinct bias against sex in general and woman in particular from which it has never wholly escaped. The church fathers give us the impression that Adam would have been both happy and sinless but for Eve. So the Council at Macon in the sixth century learnedly debated the question as to whether or not woman had a soul. The decision was in the affirmative but stated that woman suffered under serious handicaps as compared to man. The comments of the fathers on woman are damagingly coarse and vulgar. Ecclesiasticus states: "Of the women came the beginning of sin and through her all maladies."

This attitude found expression in the canon law which gave woman a position very different from the one she had attained in Roman law. As Langdon-Davies puts it: "Later Roman Law left the woman in a position of great personal and proprietary independence; from the very beginning

Christianity tended to modify this. Whenever in later Europe the Canon or Ecclesiastical law prevailed, the status of the married woman was degraded; whenever the secular Roman Law prevailed it was raised."[12]

From this older philosophy there has been a swing almost to the opposite pole. For a century all men in public life have been praising woman and exalting her as the embodiment of all virtue as compared to man the villain. It remains to be seen how successful she will be in the new rôle.

Ignoring this more or less effervescent condemnation and laudation, the beginning of the modern era found society organized about the family. People not only lived in private households but there carried on most of their industry. Law must recognize actual conditions and the father was the legal head of the household, no matter whether he or his wife dominated. Doubtless some wives were abused, certain too that some men were henpecked. The merits or weaknesses of the actual law do not concern us here. Woman's work was at home. Prostitution or the nunnery were about the only possible ways of escape from household life. To the men fell the professional opportunities.

Came the industrial revolution. Industry, save in a few cases like agriculture, left the household. It dragged out the workers, including women and children. New conditions arose and slowly custom and law were modified, not on any theoretical basis but to meet actual facts.

From a family basis we have swung to an individualism involving woman as well as man. The result is that the position of woman under the law is becoming almost identical with that of man. Amusingly enough the opposition to protective legislation for women in industry is coming from a group of supposedly emancipated women rather than from men. One by one the professions have been opened to women with the significant exception of the priesthood of the orthodox churches. Woman's educational opportunities are approximately those of man. At first woman wanted to demonstrate her capacity to take any course or pass any examination prepared for man. That having proved to be easier than was anticipated there is some uncertainty what to do next. This is equivalent to saying that we are living in a period of great readjustments and neither in practice nor in theory have we come to any definite solution of the question as to the best arrangement of the sexes in daily life. Looking backward we can see, as Maine stated, that woman has passed from a condition of status to one of contract. Once her position was fixed and others carried the responsibility. Now she may exercise her choice. It is clear that this involves the possibility that she may choose to smoke, swear, steal, even to slay, things not permitted or thinkable to the angelic creature of a generation ago. The entrance into all professions means direct competition with man. How desirable such competition is no one knows. How woman can run a profession and rear a family no man sees. Our task is to state, not to solve, the problems. The present situation may be summarized in a paragraph.

There are differences between the sexes affecting every cell of the body but we do not understand all these differences and to emphasize them in all the relations of life is foolish. Most of past and current philosophy of sex is based on half truths. What every sane person wants is the greatest possible individual development along with the best social organization. The main problem arises not in statements of ideals but in actual life. Here there is great difference of opinion. Because woman may do everything that man does is no reason for her so doing. In the 572 occupations listed in our last census women were reported as engaging in all but 35. Possibly therefore she ought to emphasize as her highest contribution the service that no man can render. Not as Luther crudely put it: "If a woman becomes weary, or at last dead from bearing, that matters not; let her only die from bearing. She is there to do it." In reality many women, as well as many men, ought never to have children. Yet group preservation remains as important as individual preservation. It may be that experience will show us that woman's primary ideal should concern the former; man's, the latter. From man's standpoint the woman who denies this is foolish. But what woman will do she must decide—and what she will decide no man knows.

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CHAPTER XIV

RACE DIFFERENCES

> In innate qualities men resemble each other;
> In habits they differ widely.
> —Chinese Trimetrical Classic

If a large number of specimens of any variety of plant or animal are examined closely, it will be found they may be divided into groups, all fundamentally alike, but one group differing from another in regard to certain details. To such groups the terms strains, breeds, varieties, and races, are applied. Such races are very common among domestic plants and animals and in the wild stock too, though we seldom know the latter as intimately. Often we apply different names to these races to avoid the necessity of constant description. If an expert is told that a certain peony root is Thérèse he knows at once just what sort of a plant and flower will be produced. These plant races differ then in flower color, in size, in time of bloom, etc. We value them as they meet our needs or tastes. Often we know when the first specimen of a new race appeared and we know just what older races were crossed to produce it, or we know the wild form from which it is a mutant.

Principles of Race Classification

Limitation to Physical Traits

It is wholly possible—indeed, the custom is almost universal—to classify mankind on a basis of race. The trouble is that a little examination will reveal that these popular classifications are not exact and are often misleading. We have no adequate knowledge of the background of any so-called human race nor do we know its relation to other races. Moreover every group of human beings has its language, culture, habits and social organization which may be quite distinct from those of a neighboring group. There is always present the danger that the word race will be made to cover some of these social matters. This is improper. If we are to use the term race with reference to man we must limit it to the physical traits which any group may possess.

It is evident that this limitation has not been observed in ordinary discussions, or, more correctly stated, so unevenly observed that one can seldom be sure just what is or is not included. Furthermore, it is common to speak of the races as superior and inferior rather than as different. Thus we start in with eyes dimmed, with judgments twisted by preconceived ideas, old traditions and prejudices. We speak of the Negroes and the Chinese as if but two races were involved whereas there are several races among the Chinese and there may be as many races of Negroes as of whites. We refuse citizenship to Japanese ignoring the fact that the Ainu of northern Japan seem to be more closely related to our ancestors than to those of the other Japanese. By contrast, in the old Austrian-Hungarian Empire there was a remarkably uniform dominant physical group in all the rival states, but the discord in their political relations has given us a mental image of distinct racial groups. In the actual world, then, we may find people of widely different racial backgrounds united under one government, accepting a common religion, speaking one language, as in the United States, or we may find people of the same or related racial groups scattered over the earth and as widely separated culturally as geographically, like the Negroes of America and Africa.

Emphasis on race as such appears to be a very recent phenomenon. The ancient Egyptian artists were able to portray race types which we recognize to-day without trouble. Differences in human stocks were known but all outsiders were usually lumped together as gentiles or barbarians and held in contempt or fear as the case might be. Doubtless they were created by their own gods. No one seems to have thought of the possibility of relationship nor did the development of monotheism greatly affect their relations. The term race was hardly used until Buffon towards the end of the eighteenth century employed it to designate varieties of organisms produced, as he thought, by the influences of soil and climate. Already the growing knowledge of the world was forcing attention to the variety of human types.

Early Classifications

Linnæus (1735) described man as *Homo sapiens* and listed as varieties, first, *ferus* (wild), giving some eight cases based on stories of children reared by animals, and last, *monstrosus* (monstrous), including three types supposed to be deformed. Between these extremes he put the American, described as reddish in color, beardless, black-haired, stubborn, contented, fond of liberty, painting his body, and ruled by habit; the European, light with fair hair and blue eyes, active, shrewd, inventive, fond of closely fitting garments and respectful to the authority of law; the Asiatic, yellowish in color, with dark hair and brown eyes, avaricious, cruel in character, fond of show, liking to dress in flowing garments, ruled by prevailing opinion; and the African, with black, woolly hair, indolent and cunning, who greases his body and lives under despotic government. Evidently Linnæus was not well informed as to the physical traits even of the Europeans. We need not blame him then for knowing so little about the rest of the world. It is to be noted that he sought to include certain mental traits as characteristic of his different groups.

In the tenth edition of his work (1789) Linnæus suggests a different classification of man whom he now divides into *albus, badius, niger, cupreus* and *fuscus,* thus approaching a classification to be noted shortly.

Buffon (1749), considering skin color, stature and body size, suggested the division of mankind into the following six races: (1) the Polar race; (2) the Mongolian; (3) the Southasiatic; (4) the European; (5) the Aethiopian; (6) the American.

An English physician, John Hunter (1728-1793), suggested in 1775 a classification based almost wholly on skin color.

Blumenbach's Classification

It remained for the man often called the "father of anthropology," J. F. Blumenbach (1752-1840), to lay a much broader foundation for the physical study of man in his work of 1776, wherein he considers not only skin color, but hair color and shape, the skull form, jaw and teeth and other stigmata. He coined the word Caucasian, which has been so much used since to designate the light-colored groups which, he thought, had originated near the Caucasus Mountains. His classification, which has been followed ever since in popular works, is almost identical with the second suggestion of Linnæus, though he reassigns some of the groups. He recognized:

1. The Caucasian: light-skinned, with red cheeks, brown hair, round skull, oval face, smooth forehead, narrow, slightly aquiline nose, small mouth, perpendicular front teeth, face symmetrical and agreeable. All Europeans except the Finns and Lapps; Asians to the Caspian, Obi and Ganges, and North Africans. It is noteworthy as Scheidt points out that no mention is made of the light-haired, blue-eyed blonds so emphasized to-day and already mentioned by Linnæus. Scheidt suggests that this may be due to the recognition by Blumenbach that his Caucasian race was the forerunner of present European races.

2. The Mongol: yellowish sallow skin; straight, thin hair on the head; almost square skull; nose small and upturned; narrow eyes; projecting cheek bones. All Asians except the Caucasians and Malays, Finns, Lapps and Eskimos.

3. The Aethiopian: dark, brown skin; dark, curly hair; long heads; broad nose with prominent upper jaw, protruding lips. All Africans except those of the north.

4. The American: copper color; thin, straight, black hair; face broad but not flat; skull often deformed. All Americans save the Eskimo.

5. The Malay: chestnut-brown skin; black hair, thick and curly; broad nose with thick lips; upper jaw slightly projecting. Malay Peninsula and many of the Pacific Islands.

This scheme had great merit and could not have been bettered in its day. It was simple and correlated certain facts of geographical distribution with physical traits. No later suggestion has won so much popular favor. Yet it is hopelessly inadequate in the light of present information.

We need not dwell long on various suggestions. Cuvier (1769-1832) appears to have been the author of the thesis that the three sons of Noah started the basic groups of mankind; Shem becoming the ancestor of the Semites; Ham of the black folk who were cursed to be the "hewers of wood and the drawers of water"; while the rest of us fell to the lot of Japhet. Leibnitz and Kant postulated four main races, as did Huxley at a later date. Agassiz thought nine would be adequate, while some students have claimed that one or two hundred races demanded recognition. Almost every physical trait has been used as a basis of classification. Still there is no agreement. The significance of this fact should be noted.

Race Criteria

Skin color is one of the most striking traits of man and it is not an accident that it has been so widely used as a basis of classification. Unfortunately it is one of the most difficult to measure accurately. The darkest members of the light-colored groups are often darker than the lighter members of darker groups. The actual color appears to depend on the thickness of the skin and the amount of pigment rather than on a difference in tint of pigment itself. Color may change somewhat as by exposure to sun and wind. We do not know how permanent it is in the history of a race. The American Indians had the color of the Polynesians but in all other regards they approached the Mongolian group to which all available evidence indicates their relationship. It is granted that we might adopt a color scale and measure the world and find out just how many folks had skins of tints one, two, three, and so on. How much would we know after we had finished?

The same criticism applies to any other single trait which may be selected. The Scotch are among the tallest people of earth but some of the Negro and Polynesian groups are also very tall, and among the Negroes we find some of the shortest people on earth; the Pygmies of Africa and New Guinea whose average stature is about 4 feet. In any group of fairly uniform descent, so far as we know, the extreme forms of any trait will be as far apart as if we were considering the differences between any two groups of no known connection. That is, the variations within any group about equal the variations between groups. It is for this reason that no generally satisfactory analysis of human races has been made as yet, a most surprising thing considering the glib use made of the term race.

The breeders of domestic plants and animals learned long ago that only by the exercise of the utmost care in mating, by the ruthless casting out of variant individuals, could any stock be kept up to standard. It has been noted in earlier pages that peculiar types of plants and animals are usually found in isolated regions. Uniformity of physical type seems to result from long-continued inbreeding with all possibility of outbreeding reduced to the minimum or eliminated. Can it be an accident that this is true of man also? As our knowledge of the world increases we find that the groups most uniform physically are living in areas least exposed to migrants from other sections. By contrast easily accessible regions show the greatest medley of traits. Compare the relatively uniform Indians of the Americas with the mixture of traits found in Europe.

Human Origins

Our problem might be simpler if we knew whether all men were of common origin, descended from one type, or not. Our traditions on this point are valueless. Yet, in spite of a few dissenters, the best opinion is that man originated somewhere in Asia along with other higher mammals and that the world has been populated by successive migrations. If these took place in early days (as we know they have in later years) the migrants must have followed the routes available at the time, "corridors" as Taylor calls them. Obviously these may have been very different from the routes of to-day. Pushing ahead to new regions—often pushed from behind, no doubt—the most primitive types would ultimately find themselves at the ends of the earth. This is a bold generalization but it is based on a body of evidence which seems to be increasing.

Early Remains

It is significant that the oldest skeletons of man have been found in western Europe, South Africa, Java and Australia, places about the most remote from the assumed starting point, barring America which was long inaccessible to man, in so far as we now know.

The remains found in Java in 1891, to which the name

Pithecanthropus erectus has been given, represent a prehuman type to judge from the size of the brain, variously estimated as having been from 710 to 950 c.c., or about two-thirds as large as the average human brain to-day.

The next oldest type known is that of the Heidelberg man, of which we have only the jawbones discovered in 1907 near Heidelberg, Germany. This man had a powerful jaw. He may have been the ancestor of the Neanderthal man described below.

The skull found at Piltdown, England, in 1911, stands next probably. The skull is thick-walled with high, narrow forehead and a small brain.

Neanderthal Man

This brings us to the best known of all early men, the Neanderthal, so-called from a skull, found near Neanderthal, Germany, in 1856 though it was later recognized as of the same type as one earlier discovered at Gibraltar. Since that date whole skeletons have been discovered in several countries, Spain, France, Belgium, Germany and Bohemia. This race had curved thigh bones, short limbs, large skulls, long heads, with big brains reaching to 1,600 c.c. at least. It appeared in Europe during the fourth glacial period at the latest and survived until about 25,000 years B.C. when it disappeared and yielded place to the Cro-Magnon. There is a strong suggestion of negroid characters in many of the Neanderthals. This Neanderthal type is represented, probably, in the remains found in Northern Rhodesia in Africa in 1921 as well as in the Talgai skull of Australia.

All these skulls indicate a strong prognathism, with heavy jaw development, and long heads, a combination of characters commonly associated with the Negro groups. Some observers think that descendants of this Neanderthal race still survive in Europe and the native Australians are sometimes placed in this group.

Cro-Magnon Man

From 1850 on, many discoveries were made of the most remarkable race of antiquity, the Cro-Magnon. Most of them were tall, varying from 5 feet 10 inches to 6 feet 4 inches (a later and shorter strain is known). The nose was narrow, the forehead high and lacking the heavy superorbital ridges of earlier races, the cheek bones were broad, creating a type of face characteristic of many present Asiatics. The heads were narrow with a cephalic index of about 71. The brains were large. They appear to have entered Europe about 30,000 years ago, possibly via Africa, and to have extended as indicated from Spain to Poland. They achieved a high culture and then disappeared, or perhaps merged with later groups, for their type is still common in France in the Dordogne.

Modern Races

The advent of the neolithic era, about 2000 B.C., brought in the forefathers of present Europeans. Disregarding the great host of tribal names found in our histories, the students are coming to recognize at least four main races and a couple of less important races as underlying the present populations of Europe. These main races are: Mediterranean, Nordic, Alpine, Dinaric.

1. *The Mediterranean.* This race followed the southern corridor into Europe, making its way even to England and Ireland. Typically they were of slender build and medium stature, with long heads and dark hair and eyes. This type survives to-day from Italy to Ireland, as shown by the Welsh and the black Irish. Its arrival in Europe probably antedated that of the others.

2. *The Nordic.* Early in neolithic times a long-headed stock, "ignorant of agriculture and pottery," made its way to the Baltic. In Russia some three-fourths of the skulls found in the mounds of the stone age are long headed. Up to the

eleventh century one-half of the inhabitants seem to have been long headed, whereas in the same regions to-day not over 10 per cent are long headed. Here we find the first of the people later called Nordics. To what extent they were like the blonds of to-day we do not know. About 500 B.C. the Teutonic tribes were in Denmark and Sweden, making their way into England at various times as in the Norman Conquest.

3. *The Alpine.* Into central Europe through the Danube Valley, in waves lasting to the time of the invasion of the Huns under Attila, came tribe after tribe of the Alpine stock, so called because found largely in the hill country. This was a heavy-set, rather short, markedly round-headed race with dark hair and eyes. It pushed down into Italy and Spain, through France to survive among the Bretons, and even reaching England. Many European students are inclined to split this race into several. The Slavs are among its latest representatives.

4. *The Dinaric.* A tall, dark, round-headed race with about the same cephalic index as the Alpine, straight or sometimes aquiline nose. Largely represented by Montenegrins, Bosnians and other Balkan groups.

Europeans often add two other races. The first was a small blond race with medium skulls, possibly represented by many western and central Russians. The second was a *tall,* brunet, mesocephalic race found along the Mediterranean. This but indicates that we are not yet in complete possession of the facts even for Europe. Very possibly all these groups were already mixed on their first appearance in Europe.

Primary Races

In as much as no reliance can be placed on single characters as tests of present races, nor as indicating the lines of descent, the attempt has been made to take a group of characters to see if we can get any picture of types prior to the creation of the so-called races of to-day. The most ambitious attempt is perhaps that of Dixon who has tentatively suggested eight primary types based on several features of the skull.

CHARACTERS OF THE EIGHT PRIMARY TYPES[1]

Types	Head	Face	Nose	Prognathism	Capacity (Brain Size)
Proto-Australoid	long low	medium broad	broad	moderate	small
Proto-Negroid..	long high	medium broad	broad	moderate	small
Mediterranean..	long low	narrow	narrow	none	large
Caspian.........	long high	narrow	narrow	none	large
Mongoloid......	round low	broad	broad	moderate	medium
Palæ-Alpine.....	round high	broad	broad	moderate	medium
Ural............	round low	medium	narrow	none	(largest)
Alpine..........	round high	medium	narrow	none	largest

Are these "types" . . . really "races"? In approaching the whole problem in the beginning, it was pointed out that physical anthropologists are not by any means yet agreed as to what are the true criteria of race, and that there is considerable doubt as to the real correlation of the various characteristics. For this reason we were led to select rather arbitrarily and by force of circumstances three particular criteria (the length-breadth and length-height indices of the skull and the nasal index) from which were derived what were assumed to be eight fundamental "types." The summary of the data given . . . has led to the conclusion that, in respect to the criteria selected and the ab-

> solute measurements on which these indices are based, the types are on the whole clear-cut units. . . .
>
> If by the term "race" we mean to describe actually existing groups of people, as I think we should, then our "types" are certainly not "races," since, with few exceptions, there are no groups of men who actually represent them. . . .
>
> We are thus led to the conclusion that the "types" whose distribution and hypothetical migrations we have, in the preceding pages been attempting to trace, are not "races" in the ordinary sense of the term, and are not to be confounded with the more or less clearly differentiated racial groups into which we may divide the peoples of the world to-day. These various living races are each the result of some particular combination of the original "types" or elements and the difficulty which we find in deciding just how many races there are is largely due to the fact that the elements have been blended so variously and in such varying proportions. Moreover from this point of view, a race is not a permanent entity, something static; on the contrary it is dynamic, and is slowly developing and changing as the result of fresh increments of one or another of its original constituents or of some new one. There is not a race in all history that has remained permanently unchanged, although the rate and degree of change have varied. Some races have retained their fundamental characteristics for millennia with but slight modification whereas others have, as a result of the incorporation of new factors, ceased to exist, because by virtue of such amalgamation they have become something else.[2]

Dixon believes that the proto-Australoids and proto-Negroids have rarely ventured out of the tropics though he thinks they reached America as well as Europe. He traces the Mongoloids and proto-Alpines to the central Asian plateaus and thinks the former were absorbed in Europe while the latter were fused with the Alpines. The Caspians and the Mediterraneans from the steppes about the Caspian, north of the plateau country, he describes as the roamers of earth. The blend of these two with the remnants of the proto-Negroids and proto-Australoids produced the Nordic.

HEAD FORM AS A CRITERION OF RACE

Towards the middle of the last century students realized that there was considerable difference in the shape of the head and that this seemed to be pretty permanent, generation after generation. Usually the head is longer than it is broad, and by dividing the breadth by the length and multiplying the result by 100 we get what is called the cephalic index. The actual range of this index in observed cases is from 62 to 103. Heads with an index of under 75 are called long (dolichocephalic); between 75 and 80 are medium (mesocephalic); and above 80 are broad or round (brachycephalic).

The Races of Europe

Ripley used this cephalic index in his great study of the *Races of Europe.* He says:

> The most conspicuous feature of our map of cephalic index from western Europe is that here within a limited area all extremes of head form known to the human race are crowded together. In other words the so-called white race of Europe is not physically a uniform and intermediate type in the proportions of head between the brachycephalic Asiatics and the long-headed Negroes of Africa. A few years ago it was believed that this was true. . . . In the high Alps of northwestern Italy are communes with an average index of 89, an extreme of round-headedness not equaled anywhere else in the world save in the Balkan Peninsula and in Asia Minor. This type of head prevails all through the Alps, quite irrespective of political frontiers . . . yet within three hundred miles as the crow flies, in the island of Corsica, are communes with an average cephalic index of 73. . . . Nor is this all. Pass to northern Scandinavia, and we find the Lapps, again, one of the broadest-headed people of the earth.[3]. . .
>
> In no other part of the world, save modern America, is such an amalgamation of various peoples to be found as in Europe. History, and archaeology, long before history, show us a continual picture of tribes appearing and disappearing, crossing and recrossing in their migrations, assimilating, dividing, colonizing, conquering or being absorbed. It follows from this, that, even if

> the environment were uniform, our pure types must be exceedingly rare. . . . We are thus reduced to the extremity in which my friend Dr. Ammon, of Baden, found himself when I wrote asking for photographs of a pure Alpine type from the Black Forest. He has measured thousands of heads, and yet he answered that he really had not been able to find a perfect specimen in all details. All these round-headed men were either blond, or tall, or narrow-nosed, or something else they ought not to be.[4]

Recently Pittard, in one of the very best books on race for the general reader, has written:

> Pangermanism and panslavism may be linguistic formulae in which political desires are enwrapped; they are not expressions of race. German-speaking people belong to many races. There is at least as much difference between a Pomeranian from the Baltic coast and a Bavarian from the Ammer massif as there is between a horse and a zebra. As for panslavism, it incorporates individuals who differ in another way as regards race. We shall see here, without quitting European soil, representatives of the Lapponic race, those of the tall dolichocephalic (Nordic) race; of the east European race (a large number of Russians); of the Ugrian race (Votiaks, for instance), and of the Turki-Tatar (Crimean Tartars) and Mongolian (Kalmuks) races. How many races, even languages and how many sociological states, squeezed into one single, redoubtable word! For us who are ethnologists it is interesting to note that these imperialistic notions were born before the great anthropological researches were undertaken.[5]

The Nordic Theory

From the time of Gobineau to the recent works of the Germanized Englishman, Chamberlain, and the American, Madison Grant, there has been cultivated a theory of the inherent superiority of the Nordics, tall and blond, to whom we are alleged to be indebted for the best in modern civilization. Naturally it has been sought to show that these Nordics were typical of the population of northern Europe. Unfortunately the facts supporting the theory are scanty. In all investigations made in Germany they appear in the minority and Pittard more than hints that an important German research was practically suppressed because the findings were unwelcome. Hertz, a recent German critic of this theory, cites an investigation made by Nystrom, who measured 500 Swedes and found that those of the upper classes were predominantly brachycephalic while those rising to prominence from the lower classes were chiefly brachycephalic. The same author quotes Wirth to the effect that the so-called German characteristics are to be found in only about 10 per cent of the Germans.[6] During the late war the German prisoners in England were studied. Their average cephalic index was 82.5 and the representatives of no part of Germany fell below 80, while the index in England is stated to be 78.24. The skull capacity of the German soldiers was higher than that of the English, higher even than that of English students. The dark pigmentation of the representatives of the lightest part of Germany was from 38 to 50 per cent, and among the south Germans was from 77 to 99 per cent.[7]

It is most desirable to know the head forms and other traits of all people but it is most dangerous to jump to conclusions as to the mental capacity of the owners of heads of any shape. What a pity that Kant, Goethe, Beethoven, Michelangelo, and Francis of Assisi, La Place, Voltaire, and Rousseau were not Nordics! What a pity that Ibsen, Björnsen, Luther, Schopenhauer, Reuter, Schubert, Schumann, Helmholtz, Rembrandt and Balzac were at best mixed-bloods! says Hertz. How much greater the pity that a scientific effort to determine facts should become the basis of propaganda of preconceived ideas!

Does Head Form Change?

It is possible that the head form may not be as stable a character as has been thought. Under the direction of Boas the heads of 2,422 males and 635 females of American-born Hebrews were measured and compared with 1,689 foreign-born males and 1,253 females. Some Sicilians were measured also.

CHANGES IN CEPHALIC INDEX

Sicilians:	born in Sicily	78
	born in America	80 plus
Hebrews:	born in east Europe	84
	born in America	81

	Foreign born	*American born*
Hebrew males, 20 years and over	83	81.4
Hebrew females, 20 years and over	85.2	82.7
Sicilian males, 20 years and over	78.1	81.6 ?
Sicilian females, 20 years and over	79.1	80.8

"It appears that the longer the parents have been here the greater is the divergence of the descendants from the European type.

"The length of head of the Hebrew is increased, the width of the head and the width of the face . . . are decreased.

"Among the Sicilians the changes are, on the whole, of an inverse order." [8]

It is surprising that the study of Boas has not been followed up by others. A recent inquiry made in Philadelphia by one of his students appears to corroborate his findings. It is possible that a partial explanation may lie in the mixed ancestry of the persons studied. Most students appear to doubt the finality of the observations.

THE SOCIAL PROBLEMS OF RACE

Race Prejudice

In the last decades some American writers have given a pseudoscientific basis to the growing mass of race prejudice held by those already convinced of the inferiority of the Negro and anxious to believe that the older American groups from northwest Europe were the special favorites of God. Until the advent of the mental tests during war-time these writers but rehashed material long familiar to those who knew the writers of Europe. It should be noted that the essence of their argument to-day is the attempt to correlate mental qualities with physical stigmata. The student has no right to assume that such a correlation does not exist—that is the thing to be demonstrated. The conclusions so widely broadcast over the country are weakened by the fact that they correspond to the prior beliefs of their authors. This means that they cannot be taken as final, regardless of the amount of truth they may contain.

The reason for the attitude here taken is shown by an experiment conducted by an associate in charge of a course on race problems. At the beginning of the term each student was asked to make a list of all the races and nationalities he could recall and then divide them into five groups on the basis of their assumed mental ability. This was done again at the end of the term. The table below shows in interesting fashion the results, with many amusing locations for certain groups, and shows also how immune our minds are to evidence when emotions are involved.

At the first of the term 231 students turned in their answers, and 234 at the end. These young men represent a fair cross section of the student body of our eastern colleges. At the opening, 26 boys thought the races about equal mentally and at the end of the course 43 had come to this conclusion. In all, over 600 students have been given these test questions and their answers have been very uniform.

Recognizing, then, certain dangers involved, what evidence is offered as to the capacity of the Negro as compared to the white? For obvious reasons evidence based on the general achievement of the groups is ruled out. It will be admitted in advance that the fool and the genius may be found in any race. The problem concerns race averages.

Change in Students' Opinions Concerning Racial Problems at the University

Before Course

Race or Nationality	Number of Times Mentioned	Per Cent Possible Points	Rank
White	108	99	1
American	75	97	2.5
German	140	97	2.5
Nordic	33	96	4.5
Scandinavian	20	96	4.5
English	132	92	6
Jew	80	87	7
Scotch	18	86	9
French	117	86	9
Dane	14	86	9
Swede	47	81	11
Irish	33	80	12.5
Norwegian	21	80	12.5
Italian	102	76	14
Spanish	66	72	15
Japanese	144	71	16
Greek	31	70	17
Yellow	133	65	18
Russian	61	61	19
Chinese	130	58	20
American Indian	102	49	21
Turk	27	48	22
Mexican	15	41	23
Negro	199	33	24

The Mentality of Negroes

All investigations indicate that the brain of the Negro is somewhat smaller and lighter than that of the white, the brains of the mixed bloods occupying an intermediate position. The first study was that of Hunt on the brains of Union soldiers during the Civil War.

The findings of Bean (1906) confirm Hunt, though

Ability as a Result of Course in American Race of Pennsylvania, 1926-1927[9]

After Course

Race or Nationality	Number of Times Mentioned	Per Cent Possible Points	Rank
White	64	99	1
Nordic	43	98	2
American	60	97	3.5
German	151	97	3.5
English	143	95	5
French	134	88	7
Dane	18	88	7
Scandinavian	31	88	7
Scotch	24	86	9.5
Norwegian	31	86	9.5
Jew	65	84	11.5
Swede	44	84	11.5
Irish	44	81	13
Japanese	145	76	14
Italian	106	73	15.5
Russian	75	73	15.5
Spanish	71	70	17
Yellow	90	66	18
Greek	41	62	19
Chinese	133	56	20
Turk	30	55	21
American Indian	79	46	22
Mexican	24	44	23
Negro	187	37	24

Bean's averages on 103 Negroes and 49 whites are distinctly lower, the Negroes ranging from 1,010 to 1,560 grams, the whites from 1,040 to 1,560 grams. The average for the Negroes was 1,292, for whites 1,341 grams.[10] Karl Pearson says: "I think we may say provisionally that for the Negro skull the capacity is about 1350 c.c. for males and 1230 c.c. for females. Clearly the capacity of the Negro skull is for males about 140 c.c. and for females 100 c.c. less than that of modern Europeans. These are significant differences."[11] There is general agreement that the brains of whites average about 1,400 grams for males and 1,250 grams for females. If actual brain weight is important the Negro males are more competent than white females. Just in passing let us notice that the brain weight of the male Chinese is said to average 1,428 grams.

WEIGHT OF BRAIN OF WHITE AND COLORED SOLDIERS[12]

Number Bases	Degree of Color	Weight in Grams
24	whites	1424
25	three-fourths white	1390
47	half white	1334
51	one-fourth white	1319
95	one-eighth white	1308
22	one-sixteenth white	1280
141	pure negroes	1331

In the light of present knowledge the claims of Bean that there are marked structural differences in the brains of whites and blacks may be much more significant. He found the chief difference to lie in the frontal lobes, the whites having a 20 per cent advantage. Todd also found that the posterior centers were relatively more developed in the Negro.[13] It may well be that observable differences in the proportion of structure of the brain are important. The difficulty is that we do not know, as yet, how to correlate brain structure and achievement. As we have noted elsewhere, some great men have had small brains and some idiots large brains. Final conclusions are not in order.

The army mental tests were devised to give a quick answer to the question of what work could best be done by the men in service. They proved quite satisfactory. Unfortunately the results have been applied, uncritically, to the question of race differences. Our confusion has been increased rather than our knowledge. The median score of the drafted whites in the combined scale (Bingham) was 13.54 ± 2.92; that of the drafted Negroes was 10.41 ± 2.79. Color is given to a belief in Negro inferiority. But does this follow? How shall we explain the fact that the median scores of the Negroes in some states surpassed that of the whites in others? Are the whites of Georgia mentally inferior to the Negroes of Illinois? Furthermore, shall we ignore the fact, officially admitted, that the tests were not equally applied to the two groups? At Camp Sherman all Negroes who had not completed the seventh grade in school were forced to take the beta tests (for illiterates) whereas the whites who had completed the fifth grade took the alpha tests but the beta tests were "limited at the top so that high grade individuals do not have the opportunity to earn all they are capable of earning." The beta test given to most of the Negroes according to the "general consensus" of examiners, "is not as satisfactory a test for illiterate Negro recruits as it is for illiterate whites." [14]

MEDIAN SCORES, WHITES AND NEGROES

Whites		Negroes	
Mississippi	41.25	Pennsylvania	42.00
Kentucky	41.50	New York	45.02
Arkansas	41.55	Illinois	47.35
Georgia	42.12	Ohio	49.50

Ignoring for the moment all criticism of the intelligence tests now so generally applied in this country to school children, the Negro children do not show up as well as the white, but the difference is not as striking as are the very uneven findings of various observers. In Los Angeles in 1922-1923 some 510 Negro children from five schools and 4,326 white children from fifteen schools were examined, the children being considered representative of the grammar-school population. The median I.Q. of the Negroes was 104.7, only 1.3 points below that of the whites. This may be compared to a median I.Q. of 101.8 for unselected children in forty schools.[15]

The extremely conflicting results of various observers must indicate great unevenness of achievement in different parts of the country, reveal striking defects in the tests themselves, or show that they are being applied by incompetent students. No wonder the Negroes wax sarcastic in their comments.

> If significant results can be obtained for Negroes as a group, they should reasonably show at least a constant trend in findings, as well as conclusions. Dr. E. L. Thorndike in tests of selection and rational thinking, generalization, and organization, for Negro and white high school students, found that *four per cent* of the Negroes passed the median of the whites for the corresponding grade; W. H. Pyle of the University of Missouri found in Negro and white high school students throughout the full course, a difference of a *year and a half* in average learning capacity; Presser and Teter of Indiana University found that they measured *one grade below whites,* and Ferguson in Virginia found them *three fourths* as efficient as whites. Ada Hart Artlett of Bryn Mawr found Negroes nearer to Italians in intelligence than Italians are to native white Americans, but along with this a larger gap between white children of different social status than between Negroes and whites; Terman of California fixed the average mental age of adults at sixteen, Trabue of Columbia fixed the Negro mental age at ten, Doll of Princeton, using the army tests, fixed the average mental age of whites at thirteen, Dr. G. Stanley Hall fixed the Negro mental age at twelve.
>
> Pyle, again, in a study of 408 Negro children in Missouri schools, found Negroes two-thirds as capable as whites and that the differences *diminished* with age; a study by a psychiatrist of the Federal Bureau of Health made in Atlanta, Georgia, found that the differences *increased* with age; Dr. Peterson of Peabody College again, found that the difference diminished with age.

Dagne Sunne of Newcombe College in Louisiana found Negro children inferior to whites on the *Binet* scale and superior to them on the *point* scale; Dr. Kwak Yeoung, a Chinese researcher, in a study of Chinese intelligence found an Intelligence Quotient of 97, which was about equal to the California whites with whom these children were compared, but higher than the I.Q. of Dr. Artlett's white subjects.

Pintner and Keller of Columbia Teachers College found the I.Q. of American whites to be 95 (less than the Chinese) the English 97, the Negro 88. The same test found the Scotch I.Q. identical with the Negro rating and the Negro rating superior to the Italian, Greek, Pole and scattered Slavic races. S. N. Derrick in South Carolina found Negro boys of 16 superior in all his tests, but the Negroes lower in all other age groups. Dagne Sunne found Negro girls averaging higher than white boys, and that while they had the largest number of below-normals they also had the highest number of above-normals. Freeman of the University of Chicago found Jews consistently superior to Americans in all age groups, Americans superior to Negroes in all but the ten year old group, and Negroes superior to Italians in all but two groups. The army intelligence tests, as has been pointed out before, found gross differences between whites and Negroes, in favor of the former; they also showed greater differences between northern and southern Negroes than between whites and Negroes; a difference between Mississippi and Oregon whites greater than the difference found by Hunter between native whites and full blooded Indians; northern Negroes superior to whites in Mississippi, Kentucky and Arkansas; and Ohio Negroes superior to native whites in every state of the south except Florida.[16]

It is useless to multiply illustrations. We do not know what the mental differences between races are and the subject awaits long and difficult investigation. This fact will in nowise deter the politician and the propagandist from continuing their activities.

Race Mixtures

Admitting the existence of different strains of human beings whose relative capacities are not accurately determined, we are at once confronted with the question of race intermarriage. It is admitted that it has taken place, but now that science is enlightening the earth shall we approve or disapprove the practice? Since the Negro is the least able in the opinion of white college boys let us begin with the question of the intermarriage of white and black in the United States, recalling that this is legally prohibited in about one-half of the states.

It is generally believed that between one-quarter and one-half of those called Negroes in the United States are mixed bloods, ordinarily called mulattoes. The estimates of the census are too low. A recent study of 1,551 Negroes showed only 439 pure Negroes (22 per cent); 97 were of Negro and Indian origin (6.3 per cent); 713 were of mixed white and Negro origin (50.8 per cent); while 294 showed mixtures with both whites and Indians (20.9 per cent).[17] Negro has become a social rather than a physical term, for the hybrid is not a Negro biologically speaking. In Cuba wherever white blood can be detected the individual is listed as white. We do the reverse. Now we have no real understanding of the differences between the pure Negro and the mulatto save that the latter usually looks a little more like the white. A striking percentage of Negro leaders have been mulattoes but this may have been due to better social opportunities. Most of the mulattoes have been the children of white fathers and these fathers have often given them better training than the pure black could give his offspring. Volumes could be filled with claims and counterclaims. One man condemns all mulattoes to inferiority and rapid extinction; the next admits their superiority. It seems to be a matter of opinion.

In the schools no marked difference in ability of full bloods and mixed bloods is found. At Hampton Institute the student body from 1901 to 1910 was classified in seven colored groups as follows:

STUDENTS OF HAMPTON INSTITUTE, 1901-1910

Color	Number	Percentage
Black	39	1.6
Dark brown	873	36.3
Brown	519	21.6
Light brown	587	24.4
Light	304	12.6
Very light	64	2.7
No trace (*i.e.*, of color)	18	0.7

Says the principal, Dr. Gregg:

> The scholastic records of these students classified by color, show that on the whole there is little difference between the different color-groups. Such variations as are found seem, it has been said, quite as likely to be due to previous schooling, or the lack of it, as to any other cause. It cannot be affirmed that any significant conclusion can be drawn as to the influence of either white or Negro blood upon mentality. In the academic record the best scholar was in the darkest group, though a slightly higher percentage of the lighter colored were marked "very good" and "good." In the work record the lighter colored showed up slightly better than the darker, in the conduct record the lighter had a higher percentage of "excellent" but a lower of "very good" and "good."

The twenty-one best Negro scholars at Hampton selected as valedictorians and salutatorians from 1914 to 1924 were:

Valedictorians	*Salutatorians*	*Whole Number*
3 dark brown	3 dark brown	6 dark brown
3 brown	3 brown	6 brown
3 light brown	3 light brown	6 light brown
2 light	1 light	3 light

"It is evident," concludes Gregg, "therefore, that in so far as color may indicate the degree of white or Negro blood, it signifies little or nothing with respect to intellectual ability."[18]

451 Male Students at Lincoln University
September, 1914, to

Color	Total	Student Years in Attendance	Group Rank	Group Grade
Very light	29	78.5	2.67	75.3
Medium light	142	350.	2.79	74.1
Medium dark	210	497.	2.96	72.4
Very dark	70	174.5	3.07	71.3

A former student has given me the table above, which is in agreement with the findings at Hampton.

In the above table the group rank was determined by dividing each class into five groups, from the highest (say 10 per cent) to the lowest (not passed) and then comparing the classes as to distribution. While the lighter groups show a trifling advantage the difference is not great.

A discussion of race problems as such does not enter into our scheme. It is necessary to say, however, that the Negro in America occupies a caste position which makes it impossible for him to be on a basis of equality with the white, regardless of the qualities any individual may have. The intermarriage of whites and blacks, then, is attacked or defended on social rather than on biological grounds. The southern white finds it necessary to maintain the Nordic antagonism to race intermixture by drastic methods. The northern white does not visualize this as likely and is indifferent. The stopping of foreign immigration and the consequent scattering of the Negro population will produce some interesting results.

Turning now to the larger question of race crossings, let us recall the earlier statement that in all great open areas there has been much blending of race stocks. This, indeed, as Dixon said, is the secret of the difficulty we encounter in trying to classify men into races. Relatively pure groups are

FROM THOSE ENTERING FRESHMAN CLASS, SEPTEMBER, 1922

Color	Total	Per Cent Dropped for Low Grades	Per Cent of Total College Group	Number for Grades
Very light	29	6.43	10.34	3
Medium light	142	31.48	10.56	15
Medium dark	210	46.56	17.62	37
Very dark	70	15.52	13.82	9

very scarce, mixed groups are common. The mixture in Europe has been noted. It is equally true of Africa and the American Negroes are not of one race. A very competent English writer has said:

> There has been much infiltration of Caucasian blood from Europe and western Asia in more recent, historic times. Pre-Islamic Arabs undoubtedly . . . were connected with and settled in Southeast Africa perhaps more than two thousand years ago. They must have taken to themselves concubines from the South African Negroes, and these last—possibly not yet "Bantu" in speech—may have already created the Hottentot hybrid with the Bushman in Southwest Africa. Then from A.D. 1000 onwards came many Arabs, Persians, Baluchis, and Hindus to the East African coast. From out the mingling of all these elements in different degrees arose the African peoples of today, very few of which are without some tinge of Caucasian blood due to the White man's persistent invasion of Africa from—let us say—12,000 B.C. to the present day.[19]

If we may judge from the millions of mulattoes who live in Africa in the Sudan and down the east coast the statements of those who predict the early disappearance of the cross between the whites and blacks must be discounted.

Even in the Americas—most remote from the assumed Asiatic center of dispersion—the Indian population is not uniform. What shall we do with the long-headed Eskimos?

How account for the low cephalic index of the Algonquins from the St. Lawrence to Georgia on the Atlantic coast and another long-headed group in eastern South America in comparison with the broader headed Indians of the Pacific coasts? What of the blond Eskimo or the blonds recently reported from Central America? Are these remnants of earlier stocks pushed by later comers to the periphery of the world?

Endless quotations are at hand showing the advantages and disadvantages of hybridization. Some biologists even have joined the social propagandists to warn us of the risks of race blending. In spite of it all there is little concrete evidence as to the inferiority of the hybrid. In reality all of this argument is to one side of the point. The problem is to find a full-blood. Where is he? Certainly not in any ancient or modern civilization known to us. Everywhere on earth this amalgamation is taking place, slowly perhaps in our southern states, very rapidly elsewhere as in our territory of Hawaii.[20]

Race Pride

What seems to have happened in history is that as each civilization has been built up the leaders have more and more stressed their ancestry, quietly ignoring earlier blends. Race pride grew. Thus the achievements became due to race. A splendid illustration of this habit can be found in our own country. The old American has been visualized as a Nordic blond. When we decided to restrict immigration we wanted a device which would let in this type of man and keep out others. Congress thought to find it by letting in a number based on an old census. When the list was made up the operation of the law was quietly suspended that a way might be found out of the dilemma.

Turn to the volume of Hrdlicka, *The Old Americans*. He studied present-day Americans whose grandparents had all been born here and in whose families there had been no crossing with later comers. The tables following show the results.[21]

PIGMENTATION OF DESCENDANTS OF OLD AMERICANS
(*Percentages*)

Sex	Pure Blonds	Ordinary Blonds	Fair	Pure Brunets	Apparent Brunets	Intermediates
Males (1,009)	3.	5.	21.	6.5	26.	53.
Females (914) ...	3.5	6.5	24.	11.	31.	46.

HAIR COLOR

Sex	Lights Proper	Light Brown (not blond)	Medium	Dark	Black	Red
Males	5.3	16.	50.	25.	1.1	2.6
Females	6.9	14.2	42.9	29.8	1.3	4.9

Hrdlicka found that 16.6 per cent of the males were dolichocephalic, 21.7 per cent brachycephalic, and 61.7 per cent mesocephalic. Of the females 8.1 per cent were long headed, 41.9 per cent were round headed, while 50 per cent had medium heads. This agrees with the older study of 486 college students in Massachusetts where 4 only had an index of less than 70, the largest number (72) had an index of 77, while 4 had an index of 87.

What all of this means is that each group comes to have an idealized picture of itself—just as devils are red and angels, white. We measure our own group by the best. We are prone to judge other groups by their worst. We idealize our own—we caricature others. If we mark ourselves 100 the rest must be content with lower places. *They* will change the scale when they make *their* own estimates. The

Nordic propaganda of the present is an extremely dangerous method of playing with fire. It is not based on proven facts. It cannot be accepted by the majority of mankind. We ought to be studying, not agitating.

Often it is stated that the downfall of some nation, say Rome, was due to intermarriage with lower class slaves or immigrants. We might just as well argue that the rise of Rome was due to the earlier blending of races for such a blending took place before Rome was. Explanation of national success or failure in terms of race will not stand investigation. At least, it will require a definition of race not yet at hand. I am neither advocating race intermixture nor shutting my eyes to certain dangers which I think to be social rather than physical. If the crossing is selective, is it a selection of the best or the worst? Each case must be considered by itself and with reference to local conditions. Dogmatic statements either for or against are entirely unwarranted.

Is Classification Possible?

Now that some of the difficulties, both physical and psychological, have been mentioned, we may return to our starting point and see what can be suggested towards a possible classification, of men not of cultures, descriptive not evaluative.

Our survey has suggested that long ago there arose a few divergent types of men which spread over earth, blending wherever they came into contact. Modern man has such a mixed ancestry that, classify him as we will, it is extremely unlikely that any lines of separation applicable to-day will be found to hold for earlier times. At various times in the past one group after another has been in the vanguard of achievement. Regardless of innate differences which some day we may be able to discover and evaluate, and the possibility of their existence and evaluation is not to be denied, we must try to keep social and physical facts distinct. Probably the leaders of the future will be those races which have the greatest opportunities, since this seems to have been true in the past.

Whatever merit the experts may later assign to the suggestions of Griffith Taylor, it is to his credit that he has made one of the briefest suggestions as to race classifications which will serve us as a condensation of the work of his predecessors:

1. Very long-headed folk, broad-nosed, nearly all have dark skins, very frizzly hair and live in the tropics.
2. Broad-headed folk, nearly all have white to yellow skins, wavy or straight hair and live in temperate lands.
3. Most moderately dolichocephalic folk have brown to white skins, thin noses, and wavy hair. They have no very definite climatic environment, but range throughout the tropical and temperate regions. It is this great range of migration which has prevented their common origin and real physical similarity from being recognized. On the other hand they invariably occupy a somewhat peripheral position outside group II and within group I.[22]

> But for the rest of the world, if the theory here proposed be true, that the social history of man is in final analysis that of the struggle for dominance among the descendants of differently dowered types, together with their gradual blending into an ever more homogeneous form, the answer to the riddle of the future would seem to be written in the past. The more primitive types and races, those least endowed, must tend to pass from the stage and merge into the complex of their victors, and among these amalgamation and absorption must continue to reduce more and more the remnants of the original types, until in the end, out of many types, through a multitude of races, may come one race, which will be the consummation of them all.[23]

Opinions may differ as to whether we are any more likely to develop one physical type of man than to create one religious sect or political organization. Yet Dixon strikes a true note in the quotation just given. Man is a part of the organic world. That world is characterized by variation and change. When we recall how other forms of life have been modified we see little reason to think that man will remain unchanged. If Europe and other parts of the world are becoming rounder-headed as some think and others fear, it may be but an indication of this change. As the world becomes smaller in so far as man is concerned the development of many given types may be more difficult and we may approximate the vision of Dixon. On the other hand man may devise some caste system and favor the creation of specialized types. Which will happen is not for the writer to predict. All he can do is to insist again that what we need to-day is more information, less emotion; more study, less agitation.

A Typical American

Consider carefully the meaning of the family chart just below, of a lad in a suburb of Philadelphia, called by his teachers "a typical American boy."

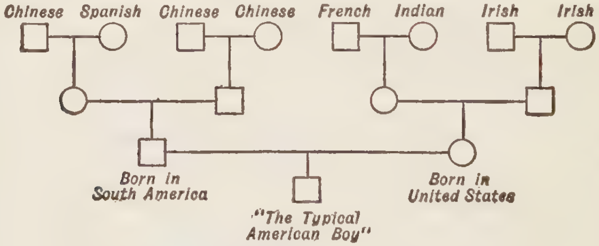

FIG. 34. "THE TYPICAL AMERICAN BOY"

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18. J. E. Gregg, *Southern Workman,* Feb. 1925.
19. H. H. Johnston, *The Negro in the New World,* pp. 29-30.
20. W. Scheidt, *Allgemeine Rassenkunde* contains a full summary of evidence as to human hybrids.
21. A. Hrdlicka, *The Old Americans,* pp. 46 and 27.
22. G. Taylor, *Environment and Race,* p. 45.
23. R. B. Dixon, *op. cit.,* p. 523.

PART IV

PHYSICS AND POLITICS

CHAPTER XV

IS CIVILIZATION SELF-DESTRUCTIVE?

My grandad, viewing earth's worn cogs,
  Said things were going to the dogs.
His grandad in his house of logs
  Said things were going to the dogs.
His grandad in the Flemish bogs
  Said things were going to the dogs.
His grandad in his old skin togs
  Said things were going to the dogs.
There's one thing that I have to state:
  The dogs have had a good, long wait.
—UNKNOWN

Closely related to the topic just discussed yet distinct enough to justify separate treatment, is the charge that civilization inevitably tends to destroy itself. The issues involved are so important that the charges cannot be ignored.

DEGENERATIVE FACTORS IN MODERN CIVILIZATION

Counterselection

A generation ago Henry Drummond[1] argued that man was upsetting the process of natural selection in ways unsuspected. The invention of tools had more or less equalized the earning capacity of men regardless of the shape of their hands, whether long and narrow or short and stumpy so that both types accomplished the same results. The invention of glasses had put the nearsighted or astigmatic man on a basis of equality with the man of good eyes in so far as vision was concerned. Drummond thought that these inventions worked against natural selection by checking favorable variations since nothing was to be gained by modification of the hands or eyes. Other observers alleged that modern customs were actually promoting degenerative changes which were held to be progressive. The increased use of sugar as food was said to be destroying the teeth, in the race, as well as in the individual. It is true that primitive races seem to have suffered less from caries. The habit of wearing tight hats was claimed to be producing a race of bald men, and it seems true that civilized men are balder than were their ancestors. The wearing of heavy leather shoes was held to be productive not only of corns but of the progressive degeneration of the little toe whose ultimate disappearance was to be expected. Man has less use for his toes than in days gone by. The accuracy of this interpretation of these facts will be considered a bit later.

Industry and Health

Other charges are based on the alleged influences of modern industry. The shift from an active out-of-door life to a more sedentary indoor life not only means less muscular development but involves, as just noted, a new exposure to certain diseases. The development of industry has led to the use of many poisonous materials such as lead and phosphorus whose effect on the workers is very harmful. No one can doubt this. Attention has been called to the dangers involved in the temperature contrasts of house or workshop and the out-of-doors. In many ways the influence of some of these things is ever more serious for woman, especially if she is exposed during the later months of pregnancy. On this point we have expert testimony.

> Women are more affected by lead than men. They suffer too from the worst types of it. Their sexual life is readily deranged by the metal. Menstruation becomes excessive and women if pregnant tend to miscarry. A large percentage of pregnant lead workers fail to reach their term. Should they succeed the infants

are either stillborn or they die in convulsions shortly after birth. . . . As already stated females suffer from the worst forms of lead poisoning. They experience severe headaches, and without having colic or wrist-drop they may pass without warning into convulsions in which they die, or if they recover from these their eyesight is temporarily or permanently lost.[2]

Among women working during pregnancy a recent study showed that of live births 6.2 per cent were premature as compared to 5.7 among unemployed mothers. The mortality rate during the first month of life was 77.3 per thousand where the mothers were employed and 39.9 where they were unemployed. Nearly 40 per cent of the employed mothers had worked until within two months of confinement and 25 per cent until within two weeks of confinement.[3]

It is freely admitted that the dust often present in such employments as street-cleaning, stone-working or mining either contains the germs of such diseases as tuberculosis, as does street dust, or by coating the lungs renders the worker less able to resist infection.

Accidents

It is charged, and not disputed, that the use of power machinery has put a new aspect on the problem of accidents. It is impossible to get accurate information as to the relative frequency of serious accidents among hunting and fishing peoples as compared to modern industrial workers but the presence of different types of accidents is evident and the unequal accident rate in different industries is revealed by the statistics of our insurance companies.

Monotonous Work

Much complaint has been made of the evil influence of the monotony involved in the tending of machinery. Modern methods appear to require much greater regularity of labor and more concentration than those of our ancestors. It may well be that adequate attention has not been given to the psychology of the matter. That fatigue bears a relation to accident needs no proof. Short rest periods have shown a marked increase in production. A weakness of present industry may lie in the inability of the worker to think in terms of the finished product. In a school for the feeble-minded a rug-making machine was introduced which the children liked to work. After a time the institution tried to have long strips of carpet made but the children lost their interest. Finally, one boy in reply to a question said: "Oh, you don't never get anything done." The hint was taken. The children were put to work on short strips easily finished by individuals. The machine became popular again. They couldn't distinguish their share of the long pieces. When, however, Jack London ascribes his wandering habits to the monotonous employment of early years a question is raised as to whether this is a reason or an excuse. Men like Jack London and Josiah Flynt are seldom steady workers.

Antisocial Selection

The complaints are by no means limited to industry. It is alleged that medicine and surgery, in the long run, are harmful in their results. They too interfere with the beneficial operation of the law of natural selection. Often they save the weaklings who without them would perish and make it possible for them to become parents. The woman with a narrow pelvis, physically unfit to become a mother, instead of dying in childbirth is saved by an operation. She lives but has no more children. The family is saved at the expense of the race for, otherwise, the widower would have remarried and had other children as the tombstones in old cemeteries indicate. Thus the healing art benefits the individual but harms the race. Furthermore it imposes a financial burden on the survivors who must care for the wrecks unable to maintain themselves.

To some extent all the foregoing charges contain a criticism of social ideals and customs, for the doctor in the long run does what society wants. He cannot be held responsible for what society later allows to happen. There are, however, certain specific complaints of current standards deserving of notice.

Population Problems

The Declining Birth Rate

It has been noted in all civilizations by careful observers that the birth rate was falling. "In my day all Hellas suffered from childlessness, and from lack of population, to such an extent that the cities were emptied and the earth did not produce its fruits, though neither uninterrupted wars nor pestilences had fallen to our lot. Man had succumbed to vanity, to lust of gold, to laziness; he would not marry, or if he did, he raised no children." So wrote Polybius in the second century B.C. Later Greeks voiced the same complaint. The old Greek population seems to have been replaced by newcomers, only the larger towns preserving even their old Greek names. This appears to have happened many times in history. It is well known that the rate of population growth has fallen recently in civilized lands despite the tremendous expansion of the last century. This is shown in the graph in Figure 35.[4]

We are not now concerned with the question as to whether a fall in the rate of population growth is in itself a good or a bad thing. From the standpoint of the critics the significance lies, in large part, in the belief that the decline comes chiefly in the groups best fitted to become parents. The charge, then, is that the change is not only one of quantity but also of quality. This merits far more careful inquiry than can be made here and a mere outline must suffice.

Man is distinguished from other animals by the lengthened period of care for the young. The child of primitive man becomes independent of parental support much earlier than does the child of civilized man. The child destined for professional life cannot become self-supporting until he is much older than one who is to earn his bread by unskilled labor. The cost of this added training steadily increases and the burden on the family exchequer rises. On these facts all are agreed. Moreover, in agriculture—and to a lesser extent in unskilled trades—the children become workers, that is, family assets, long before they start out for themselves.

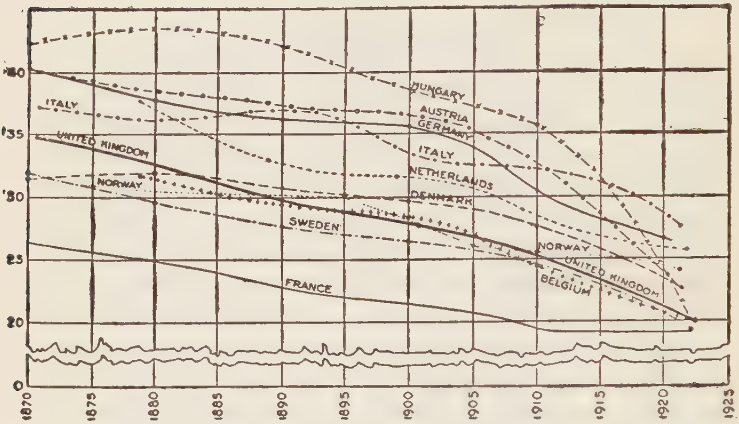

FIG. 35. THE DECLINING BIRTH RATE IN EUROPE

Smoothed curves based on decennial census enumerations of population and average number of births reported for groups of five years, of which the census year is the central year. This graph disregards short-time fluctuations due to wars, famine, business cycles, and the like. Post-war figures are for the latest single year available. (From Louis I. Dublin, *Population Problems in the United States and Canada,* Publication Number Five of the Pollak Foundation for Economic Research, Houghton Mifflin Co.)

The net result of these things is the creation of a differential marriage rate and, consequently, a differential birth rate. It is charged, further, that they lead to anti-family ideals which make the situation even more complicated. What is the evidence on these points?

Marriage Rates

Among most primitive folks marriage appears to be almost universal and to be celebrated soon after puberty. The Mohammedans encourage the marriage of the girls from thirteen to sixteen years of age and the boys of seventeen to twenty. The factory hands and miners of Prussia before the war married almost six years earlier than public officials. Finland and parts of Sweden showed a difference of five years between the laborers and officials as to date of marriage. Of the latter only 6.4 per cent were married under the age of twenty-five; of the former 35.1 per cent. In 1912 the German Post and Telegraph Service reported that 90 per cent of its higher officials under the age of thirty were unmarried as against 49.4 per cent of the same age group in the general population. Between the ages of thirty to thirty-five the percentage of unmarried was 32.8 as against 22 for men in general; from thirty-five to forty it was 25 as against 13.1; but in the age group sixty to sixty-five it was only 2.3 per cent unmarried as against 7.1 in the general population.[5]

The figures from England show a rising age at marriage which has affected all classes but rests most heavily on the upper groups. In the table on the following page the age at marriage is shown for recent marriages, those of from 0 to 5 years, and older marriages, those which had lasted from forty to fifty years. The figures are drawn from the 1911 census.

The average age of the bride, 1906-1911, was 25.3. Miners married the youngest women, 23, the upper and middle classes the oldest, 26.6. Schallmayer states that the English miners and textile workers married seven years

AGE OF WIFE AT MARRIAGE[6]

Group	40-50 Years Duration	0-5 Years Duration
I. Upper and middle classes	23.0	26.6
III. Skilled workmen	22.1	25.1
V. Unskilled	21.9	24.8
VI. Textile workers	21.8	25.1
VII. Miners	21.2	23.6
VIII. Agricultural workers	22.2	24.8

earlier than the higher officials, the women of the first groups three to four years sooner. MacIver says: "Civilization does not seem prejudicial to marriage itself. The frequency of marriage does not seem to be lessening as compared with past periods, though there is no exact evidence on this point." [7] The significant thing is the delayed marriage of the upper groups.

Delay in marriage automatically reduces the number of children. Galton estimated that the marriage of women at the age of twenty as compared to their marriage at the age of twenty-nine meant eight children as compared to five. The following table is from Germany.[8]

Age of women at marriage	Under 20	20-25	25-30	30-35	Over 35
Average number of children	5.53	4.48	4.11	2.93	1.34

The age at marriage of men is of lesser importance but is not negligible.

Age of man at marriage	Under 25	25-29	30-34	35-44	Over 45
Average number of children	3.50	3.25	3.62	2.28	1.10

Marriage in the United States

The evidence from the United States shows a similar situation. Lotka states that in the eighteenth century there were 7.8 children per marriage, which is much larger than in present families.[9] Ninety per cent of all women who marry do so under the age of forty, but only 45 per cent of women college graduates marry before that age. The average age at marriage of women college graduates is 26.3 as against 24 for their sisters and other near relatives. About 15 per cent of our women do not marry during the childbearing years.

The percentage of childless wives appears to be increasing. Crum studied the genealogies of New England with the following results:[10]

Percentages of Childless Wives

1740-1799	1800-1849	1850-1869	1870-1879
1.88	4.07	5.91	8.10

The evidence indicates that the older American stock is not reproducing as fast as that of more recent immigrants. J. A. Hill found that in every ten marriages the following number of children might be expected:[11]

Native-born women	27
Negro-born women	31
English-born women	34
Russian-born women	54
French-Canada-born women	56
Polish-born women	62

Differential Birth Rates

In as much as there is some correlation between social position and the possession of wealth we may expect to find some association between wealth and the lack of children. This is brought out in the following table:

BIRTH RATE ACCORDING TO DEGREES OF WEALTH IN DIFFERENT ECONOMIC STRATA IN EUROPEAN CITIES[12]

Average number of births annually per 1000 women from 15 to 50 years of age

City	No. of Years	Very Poor	Poor	Well Off	Very Well Off	Rich	Very Rich
Paris	5	108	95	72	65	53	34
London ...	9	147	140	107	107	87	63
Berlin	9	157	129	114	96	63	47
Vienna ...	5	200	164	155	153	107	71

The United States census of 1910 indicated that in certain selected districts 13.1 per cent of the native white women who had been married from ten to twenty years had borne no children, while only 5.7 per cent of the women of foreign parentage were childless. One woman in eight of the native stock was childless, as compared to one in twenty of the foreign. Of the second generation in America, 6.3 per cent of the women had no children. The white natives had borne a child every 5.3 years, foreign whites every 3.2 years. Women of English parentage had a child every 4.3 years; those of Polish parentage every 2.3 years. City communities showed the highest percentage of those having no children. The average number of years married per child born was 3.8 in Rhode Island, 3.5 in Cleveland, 3.6 in rural Ohio, 4 in Minneapolis, and 2.8 in rural Minnesota. It may well be that these figures indicate a replacement of the older by the newer stocks.[13]

Family Degeneration

I recently examined 150 Irish families in northern Pennsylvania, who are now in the second American generation. These families were of the best classes that emigrated about the time of the famine of 1847. With two exceptions (where the fathers became drunkards here) they gave the children the best example; they all succeeded financially so that their children were well fed, well housed and educated: nearly every family was able to send some of its sons to college. In the first American generation there were 5.52 children on the average to each family. If there were a full progression at this rate, these fifty families should now be represented by 1,523 persons. The total, however, in the second generation will not reach 200 persons and I am practically certain there was no prevention of conception.

In the first American generation there were 276 children, 149 males, 127 females. Of these 53 men, over 35 per cent were chronic alcoholics, public drunkards; 6 of the women were also public drunkards. Twelve of the men and four of the women became insane.[14]

Causes of the Declining Birth Rate

If it be admitted that modern society shows a delay of marriage and a birth rate which is both lower and differentiated we may ask what is known about the *causes* of these phenomena. The reader must be warned not to assume that a low birth rate necessarily means a slow increase of population. All depends on the accompanying death rate. The New Zealand birth rate in 1855 was about 42; in 1910 about 26. The fertility rate steadily declined from 337.2 per thousand married women in 1878 to 226.6 in 1906. But the death rate fell also from about 17 in 1860 to a little over 9 in 1910. The result is an excess of births over deaths of about 16 per thousand enabling the population to double in forty-four years and to increase 4.8 fold in a century. The net increase is rapid although the birth rate is low. The present high birth rate among the poorer families of civilized lands would be accompanied by a high death rate were it not for philanthropy. It is quite possible, if all the facts were before us, we should find that the same differential birth rate had obtained in all ancient civilizations. The causes of this differential rate are important. To this all agree, but there is much difference of opinion as to the causes themselves. They appear to fall into two groups which, for purposes of discussion, we will call (1) incidental, and (2) intentional.

Migrations

Foremost in the incidental group we may place the vast recent migrations to the newer areas of earth which have left a surplus of women in the homelands and caused a scarcity of them on the frontier. No woman on the American frontier was without chance of marriage; many New England women found no men of their own group available. This is even more true of Europe. Temporarily, at least, this migration increased the percentage of the unmarried. This has been the result also wherever men have been gathered in military training camps or armies for several years. To some extent it is seen where occupations like commerce have taken men away from home for long periods. Marriage has been delayed, at least, in all these cases. The necessity of supporting parents or other relatives has often interfered with marriage.

Celibacy

Celibacy, however, may be the result of some ideal and thus fall into the intentional group. It appeared as a religious ideal in the old Roman Catholic Church though it was not strictly enforced among the priests until about the year 1000. In view of the great number of able men and women who have come from the homes of Protestant ministers in such numbers as to cause wide comment, the enforced celibacy of priests and nuns takes on added meaning. In some instances celibacy is due to the refusal of some high-minded man or woman to perpetuate known heritable defects. How common this has been no one can tell. Celibacy may come from far more selfish motives: the desire to be free and independent, the refusal to assume the burden of bearing and rearing children, whether the reasons alleged be financial, social or religious, for Tertullian said that "no righteous man would willingly have desired sons."

Childlessness

Celibacy and childlessness are, of course, quite distinct. The absence of children in some families is wholly due to physical incapacity, but the courts seldom find that this is the actual cause of a divorce suit. The commonest involuntary cause appears to be venereal disease. Hyde of Chicago saw some 1,700 cases of syphilis in pregnant women: 578 (34 per cent) resulted in miscarriages or stillbirths; 956 living children were born only to die within the first twelve months. That is, 1,534 (90 per cent) of the 1,700 offspring did not live a year. Many of those surviving longer were crippled by the disease. A German physician reported on 153 cases where the father was syphilitic; 120 were stillborn; 25 died shortly after birth; only 8 (5.3 per cent) lived over a year. While these figures are extreme there is general agreement that syphilis destroys over 50 per cent of the children. Syphilis, however, does not ordinarily produce sterility. This rôle is played by gonorrhea, a more common disease, which causes over 50 per cent of the involuntary childless marriages in the opinion of medical men. A few other diseases like measles and mumps occasionally cause sterility. Exposure to venereal disease is generally increased by the social arrangements above mentioned which delay marriage.

Abortion

Abortion is common both in Europe and America, not only in cases of illegitimacy but as a regular practice of some families. The estimates for abortion in the United States range from 250,000 to several million per year. This may be compared to the total of births, about 1,500,000. Abortion seems to be as common in Germany as here, to say the least, while in France it is said to equal the birth rate. Popenoe feels that it is increasing.[15]

Contraception

There are few who question the statement that voluntary avoidance of conception is the chief cause of the low birth rate of the educated classes in all western countries. Even the Roman Catholic Church does not oppose family limitation brought about by self-control. It holds, and this is the position of the law of some countries, that contraceptive devices should not be sold, nor physicians allowed to instruct patients even on health grounds. Despite this attitude there is little doubt as to the facts. In Holland the poorer classes have been taught methods of contraception under public auspices with results said to be beneficial. A change of sentiment elsewhere is evident as is shown by the increase in clinics and in public discussions. Entirely apart from the merits of the argument, the amusing fact remains that the immediate results of wider information would probably increase, not diminish, the differential birth rate. The diagram opposite seems to furnish adequate evidence as to the present situation.[16]

Problems of Social Control

Prohibition

In the chapter on Race Differences it was noted that diseases attack some races more than others. Whether this is due to some original quality of the body or to some immunity acquired by long contact with the disease involved is disputed. Certain it is, in some cases, that the resistance varies with the length of exposure. Hence it has been argued that children ought to be exposed to many diseases lest they take them in later life with more serious results.

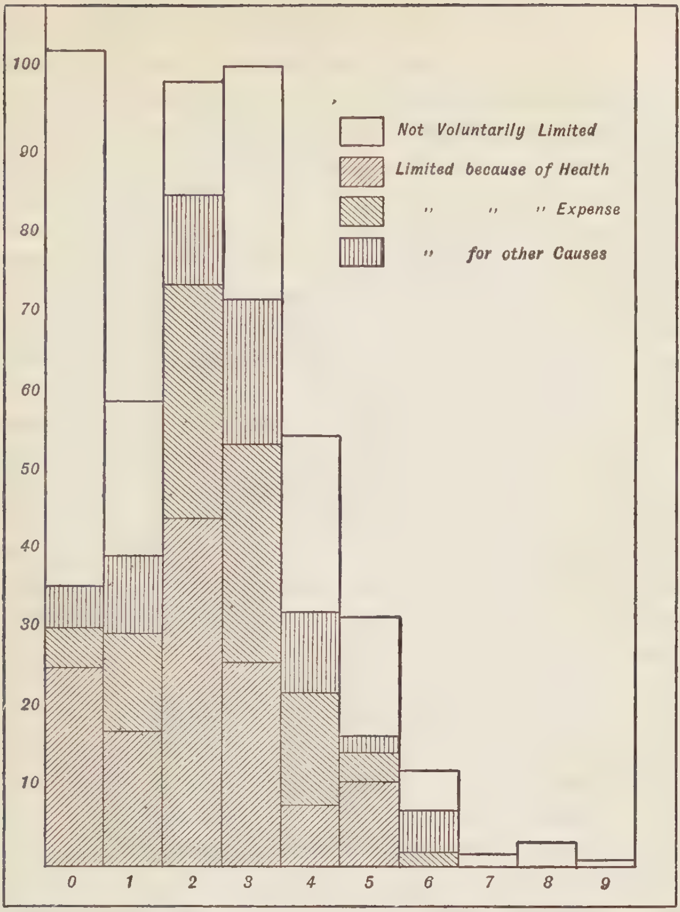

FIG. 36. THE FAMILIES OF 461 AMERICAN SCIENTIFIC MEN

The figures at the bottom indicate the number of children to a family; those at the left the number of families of equal size. The chart shows for each size of family of 461 American men of science in how many cases the limitation was involuntary and in how many cases it was voluntary. The shaded areas, showing the number in which it was voluntary, are subdivided to indicate the causes. Thus, when the marriage was childless, this condition was involuntary in 67 cases and voluntary in 35 cases. The reasons assigned were health in 25 cases, expense in 5 cases and other causes in 5 cases. In the family of two, the limitation was voluntary in 84 out of 98 marriages. The reasons assigned were health in 44 cases, expense in 29 cases and inconvenience or other causes in 11 cases.

This has been a common practice here as regards measles and chickenpox. The public health movement has been condemned as allowing the survival and reproduction of nonresistant stocks. The same argument has been applied to efforts to forbid the use of drugs. The use of alcohol as a beverage has been opposed because it was said to injure the germ cells and lead to the production of abnormal types. The evidence of this race injury by alcohol, as earlier noted, is far from satisfactory. If alcohol could cripple a race it is hard to understand why so many of us are normal, for intoxication was far from rare among our ancestors. Alcohol does affect some folks more than others. Hence a few men, like G. A. Reid in his thought-provoking work, *Alcoholism,* are inclined to favor what has been called, "an open-door-to-hell" policy. Reid argues that in groups long accustomed to the use of alcohol, like the Jews, the susceptible types have been killed off, leaving resistant stock not likely to be injured. By contrast the Irish to whom adequate supplies of alcohol are more recent still suffer greatly. The prohibition program then is all wrong. Physicians know that some deep-seated disorder is often the start of alcoholism and that the latter is as often a result as a cause, but present thought does not seem to favor Reid's ideas. The opposition to alcohol, opium, peyote and other drugs is growing and tobacco even is being attacked. Tea and coffee will come next, for the fires of reform demand fuel. The thoughtful observer will note that the antagonism is now based on considerations of health, which are quite apart from the older attitude that anything enjoyable must be wrong.

War

It is doubtful if any human program has been more extravagantly praised and condemned than war. On the one hand it has been lauded as the divinely ordained method of annihilating inferior stocks of men. Even in combat between two antagonists it has been assumed that the weaker lost. War has been defended as the application of the principle of natural selection to human affairs although this was denied by such men as Darwin, Wallace and Kropotkin, who asserted that coöperation, not competition, was the key to human achievement. On the other hand, the antagonists of war have pointed out the terrific cost of war both in money and men, the suffering of noncombatants, the destruction of social standards. They argue that the best fitted men of contesting groups are killed and the general average of the group lowered. In reality the loss in men is most easily repaired. Probably every country involved in the late war has a larger population to-day than it had in 1914. That war has some selective effect must be admitted. The Englishmen who volunteered at once and went to the front may easily have been of higher type than the later draftees. Modern warfare does not lead to the extermination of peoples, even in such extreme cases as the massacres of the Armenians. Since bullets and gas are no respecters of persons, in so far as the army represents a cross section of the population, it is hard to see any special selective force exercised by modern warfare unless there be some arrangement which puts the most competent men in the front line and the mentally inferior in the rear where danger is least. To some extent this is true. The most serious effects of war seem to be social rather than physical; economic rather than biologic.

Caste

Complaint has been made that a caste system such as that of India, whatever its early merits as a solution of group relations, is harmful to society in the long run. The upper classes do not have to strive to maintain their position; the lower classes lose ambition to achieve. It is argued with much force that the perpetuation of artificial distinctions by law and custom is bad. In the western cultures of to-day little limitation has been put on the development of the member of any group, yet the development of a caste system in so far as the Negro is concerned is a common American suggestion. The inherited nobility of Europe has not been very long lived. It is claimed that in France ten generations, say three hundred years, has been the limit for noble families. Of 280 houses only 20 passed the title to the eldest child nine or ten times. Among the Nobles of the Robe the average family lifetime was 230 years. This seems to have been true also in the aristocracies of Germany and England.[17]

Philanthropy

The critics of modern society make their chief attacks against our philanthropic programs. The argument is not that we ought to neglect the unfortunate or permit needless suffering, but that in caring for the individual we have forgotten the race. There is much truth in the charge. We save the lives of the incompetent, we educate them to some extent and encourage their marriage with the result that society is increasingly burdened financially and otherwise. Left to themselves many would perish and leave no descendants. In the discussion of human heredity it was shown that there was a real danger of the formation of defective strains. When a taxpayer finds eleven children of one couple being supported for life in a Pennsylvania institution, he may well ask why he should pay the bills. In 428 German families there were 1,705 children who lived beyond infancy, of whom 600 (35.6 per cent) were feeble-minded.[18] In addition we have to deal with the great families, socially as well as mentally degenerate, such as the Jukes, Ishmaelites, and Nams, where the reproduction rate is high and where the chance of any child getting a fair start in life is exceedingly small regardless of its mental equipment. It must be admitted that these groups constitute an unsolved problem. The answer to the charge, however, is not a return to the older policy of neglect but an advance to greater control by society.

Homicide

The increase in all civilized lands of suicide and homicide is claimed to be another indication of the degeneration taking place. Between 1900 and 1911 there was an increase in suicide in the United States from 11.5 per hundred thousand of population to about 17. Since that date it has fallen somewhat. Suicide is often an indication of insanity. Schallmayer states that on later examination of 124 persons who had tried unsuccessfully to commit suicide only one, a pregnant girl, was found normal: 44 were obviously insane; 12 were epileptic; 10 were hysterical; 28 were chronic alcoholics and 29 were emotionally pathologic.[19]

The homicide rate climbed steadily in the United States from 1900 to 1926, according to Hoffman, reaching a total of over 11,000 per year. We have twelve times as many homicides per thousand of population as England and five and one-half times as many as Canada. In 1916, London, with a population of 7,250,000, had only 9 murders while Chicago with only one-third as large a population had 105. Murder is twice as common here as in Italy, which has the doubtful honor of standing second. In cities of a million or over the 1924 rate (10.3) was twice that of 1900.[20] If it be true, as criminologists have asserted, that the normal course of crime is from assaults on persons to property offences, it seems that we have reverted to more primitive conditions due perhaps to the survival of the feeble-minded and other degenerates or else that we represent for some reason a social frontier.

THE CHARGES AGAINST CIVILIZATION

Biological and Social Remedies

In this hurried survey we have glanced at most of the charges brought against civilization. That many of the problems raised are large and important no one will deny. We have not and shall not discuss the problems or the proposed remedies. We must, however, consider briefly the accuracy of the analysis on which the charges are based. It will be recalled that we began by stating that they rested on two general grounds, interference with natural selection, and the development of bad morals.

A little reflection will show that, if the earlier discussion presented the facts, most of the charges based on the alleged interference with natural selection are not well founded. The older explanation put the cart before the horse. Whatever the causes of variation prove to be, all present evidence indicates that neither use nor disuse of any bodily organ is included. The use of spectacles has nothing to do with causing or preventing future variations of the eyes. That many persons would have to change their careers were it not for glasses is granted, but fitness for a given calling involving heavy use of the eyes, say school-teaching, depends on many things besides eyes. So, too, the harm done the individual, great as it may be, by modern industry does not alter the race stock. The children of European migrants to America or Australia have often proved stronger than their ancestors when given a more favorable environment and better food. The real secret of the riddle lies in the fact that the hardships suffered by the parents often produce a bad social environment for the children. Thus a physical injury while not affecting the race stock may lower the standard of living for the family and produce dire results. The importance of this distinction lies in the fact that it indicates the remedy. Bad conditions may not be defended on the ground that they do not alter the race stock, for the creation of bad living conditions is quite as serious. The remedy lies, however, in social, not biological, fields. Present policies may be very bad. We can control environment to some degree, if we will.

Physical Imperfection

One main reason for the protests against civilization is that only recently has man discovered that he is far from perfect physically. Ignorant of earlier societies he tends to think that this is a recent phenomenon. There is no justification for this belief. What is happening, as in the case of the eyes, is that present use is revealing unsuspected facts. The eye was not made for long-continued study of small objects at close range. When this becomes necessary imperfections are revealed. To discover that less than 10 per cent of our children averaging eight and one-half years of age have good eyes and that 60 per cent need medical attention but reveals what sort of eyes we have. Of the children examined 88.11 per cent proved to have farsighted eyes, 4.27 per cent, nearsighted, while only 7.51 per cent were blessed with so-called normal eyes. "Simple visual acuity tests made on 42,275 students in 22 colleges and universities showed defective vision varying from 15.6 per cent to 51 per cent and averaging 37.7 per cent. The laboring class showed a range of defects from 48.3 per cent to 713 per cent—averaging 53.6 per cent." That which is thus shown to be true of the eyes is equally true of the body as a whole.[21]

The table below, taken from an article by E. L. Fisk, the head of the Life Extension Institute, indicates how few men are physically sound, and how the judgments of observers differ. Normal vision is not perfect vision. The normal man is far from being an ideal (as every wife discovers sooner or later).

How Many Are Physically Perfect? [22]

Class	Defect	100 Post Office Employees Life Extension Institute	985 Post Office Employees United States Public Health Service	Rate per 1,000	Rate per 1,000
I...	No physical defects	0	5	0	5
II...	Minor defects requiring observation or alleviation	0	12	0	12
III...	Moderate defects, requiring hygienic correction or minor medical, dental or surgical attention	5	258	50	262
IV...	Moderate defects, requiring medical supervision as well as hygienic correction	26	336	260	341
V...	Advanced impairment demanding systematic medical or surgical attention	57	234	570	238
VI...	Serious defects requiring immediate surgical or medical attention	12	140	120	142

In as much as men are not physically perfect, probably even if they were born perfect, the experiences of everyday life are bound to cripple them, to reveal hidden weaknesses. The problem of society is to minimize these bad results and to limit their effects in so far as possible to the individual. Biology knows nothing of any progressive degeneration of the race stock coming through social policies, but it often sees men needlessly weakened both by bad habits and bad social conditions.

Bad Morals

The onus of the complaint against civilization rests, then, upon the second charge, the development of bad morals, both the individual "habits that handicap" and bad social selection. In other chapters it is shown that the development of wise social choices is the chief concern of society. Of course it is foolish to save the lives of degenerates and then allow them to procreate offspring for whom they can provide neither adequate support nor training and to whom often they cannot bequeath adequate brains. To save the individual and ruin society is but a slow method of suicide. Just how this riddle is to be solved we have not ventured to suggest. Nor have we discussed methods for securing a higher birth rate among those fitted to become ancestors.

It seems clear that much of the thinking and discussion of these matters has been confused. Often it has started from unsound biological assumptions and has sought to find a biological remedy where the solution appears to lie in the development of social standards and ideals. New conditions of life demand new customs if trouble is to be avoided.

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CHAPTER XVI

SOCIAL INSTITUTIONS

The ancients who wished to illustrate illustrious virtue throughout the Empire, first ordered well their own States. Wishing to order well their own States, they first regulated their families. Wishing to regulate their families, they first cultivated their persons. Wishing to cultivate their persons, they first rectified their hearts. Wishing to rectify their hearts, they first sought to be sincere in their thoughts. Wishing to be sincere in their thoughts, they first extended to the utmost their knowledge. Such extension of knowledge lay in the investigation of things.

Things being investigated, knowledge became complete. Their knowledge being complete, their thoughts were sincere. Their thoughts being sincere, their hearts were then rectified. Their hearts being rectified, their persons were cultivated. Their persons being cultivated, their families were regulated. Their families being regulated, their States were rightly governed. Their States being rightly governed, the whole Empire, was made tranquil and happy.

It cannot be, when the root is neglected, that what should spring from it will be well ordered.

The Great Learning (Chinese Classic)

What Society Is

The secret of man's success in dominating other forms of life and in gaining control of the natural environment lies quite as much in the fact that he is one of the social animals as in his intellectual equipment. The latter alone would be wholly inadequate. It is society which enables man to utilize the discoveries made by individuals. The concept *society* involves much more than a mass of individuals who collectively comprise the population. While the individual is the unit of population it is the relation between individuals which is essential to society. Society exists, as MacIver says, "wherever individuals maintain willed-relations to one another." Furthermore it is evident that these "willed-relations" cannot be antagonistic. No society could exist where men always opposed and fought each other. Coöperation for common ends is requisite. We need not stop to survey the little we know of early times nor to debate the extent to which this coöperation has a conscious base rather than one of emotion; both elements are present.

We are forced to assume that the character of an individual is the resultant of the development of natural, inherited qualities under the influence of the world about him, social as well as physical. In as much as no two persons are just alike, and since the environment of no two persons can be identical, it must follow that differences will arise in the wants, ideals and judgments of men. Hence, society always faces the necessity of developing standards to avoid the evil effects of the clash of interests that would otherwise arise. Throughout the ages moral education has been at least as important as the acquisition of facts which is so emphasized to-day.

Group Standards

But mankind does not function as one great group. The average man is a member of some local group, often small in numbers and isolated from larger groups. The result is not only the development of peculiar local customs but the establishment of a group morality which, in time, may be elevated into a system of ethics and attributed to some deity. As a rule the group is satisfied if it secures uniformity of conduct on the part of its members. More rarely the attempt is made to secure uniformity of belief. To secure these results man has resorted not only to the teaching of the young by precept and example but has everywhere used ridicule, threat, or punishment, even to the extent of taking of life or expulsion from the group, the two being practically synonymous in earlier social stages. The efficacy of the means employed or the degree of success obtained need not be considered. For argument's sake we may assume that an isolated group like the Eskimos, in a relatively fixed environment, might work out a happy solution and conduct their life for ages with few changes and few new problems. Sooner or later, even for the Eskimo, comes the contact with another group of different culture and a conflict of custom arises. Are the old group standards to be applied to the members of the strange tribe? Early man thought not. Not infrequently race differences are present and the struggle becomes more acute. History teems with illustrations of various solutions from the extinction of the weaker group, or the absorption of one by the other, to some final form of toleration. Even to-day we are witnessing the tardy evolution of world standards now that all groups are more or less in contact.

Similar problems often arise where a large area is under the control of a single government, whether race complications are or are not involved. Differences in local conditions are so great in America that serious friction is bound to arise even though in general a single code of morality be accepted. Even in a given smaller area group interests may be very divergent, as in a modern city. Every man speaks with some background of interests. The one hundred per cent American is a creation of our imagination. No man knows or represents the social whole when the whole includes hundreds of millions. The Congressman who forgets the situation of his local constituents is soon forgotten himself.

If this crude sketch be roughly correct we may seek to analyze social institutions a bit more in detail. It is indicative of the present status of "social science" that no scheme of analysis is generally adopted nor is there one wholly satisfactory to its maker. In part this arises from the difficulty of giving exact values to common terms. The attempt to escape from this difficulty involves the use of an artificial terminology which few will master or accept. Much more serious is the fact that our present information is too meager to justify complete analysis. All that can be sought is to mention some of the things which seem to be fundamental.

Roughly stated it appears that society must try to standardize man's relations in at least four matters: (1) The use of the physical environment. (2) The use of wealth. (3) The relations of man to man. (4) The relations of man to the gods.

Evidently no one statement could cover all historical or present groups. Every group has had some standards with reference to the use or ownership of land and its products, water rights, hunting rights, mineral rights, etc. So, too, each group makes its own decisions as to the use, ownership, inheritance of wealth, whether one has in mind the simple tools and clothing of the savage or the complicated forms of modern wealth. The relations of the sexes, of children and adults, of natives and foreigners adequately illustrate the third group. The whole gamut of practices from the lower realm of magic used to secure personal benefit or to harm an enemy, to the highest ethical teachings of self-sacrifice for the welfare of others, the emphasis on certain things as leading to heaven or hell indicate the range of the fourth group.

Classes of Social Institutions

The situation may be stated in another way. There appear to be four major interests in the life of man, universal and permanent. To meet these interests there are four groups of institutions found among all peoples and everywhere considered important. These are:

Interests	*Primary Institutions*
1. Self-preservation	Economic institutions
2. Group-preservation	Political institutions
3. Race-preservation	Domestic institutions
4. Soul-preservation	Religious institutions

In as much as such an analysis is intended to be suggestive rather than complete there is little occasion to attack or defend it. It calls, however, for a bit of explanation. To begin with, we must remember that we think of our life as a unity. It is not sharply separated into departments. When we draw such distinctions we do so for the sake of clearness of discussion.

The interests named appear to fall into two distinct groups. The first three deal with man's relations to the outer world whose phenomena are matters of observation. The fourth is the result of introspection. The critic may object to its inclusion. The term soul-preservation may be unsatisfactory. Yet I know of no better term to convey the idea of personal integrity, the faith in immortality of personality, which every one must admit as having played a rôle in history. No one can deny that religious institutions have been, and are, very powerful. They cannot be ignored even if they are hard to classify.

The student knows full well that these great institutions did not arise overnight, nor have they been kept separate and distinct, whether one considers any given group over a long period of time, or compares their rôles in different groups. Doubtless they arose together. They overlap in endless fashion. All are found in every social group and there seem to be no others to be compared to them in importance. Now one is emphasized or made almost dominant, now another. Some one may suggest that educational institutions are important. Granted. Only in well-advanced societies have these developed save as functions of one of the others. A complete table would require many subheads, such as judicial, medical, or charitable institutions, whose present value is beyond question. We have to deal, then, with those comprehensive, fundamental institutions which I have called primary, and also with their later offspring, the secondary institutions, such as educational, which appear as society develops and functions are subdivided for administrative purposes. Secondary, therefore, does not mean unimportant.

By contrast consider the crowd which collects about a street fight to cheer the winner, or the enthusiastic volunteers who rush to the fire and act as if bent on seeing how much they may add to the destruction of property. The incident over, they disperse and the matter is closed unless some wealthy eccentric creates an endowment, or the hope of pensions leads to organization. Temporary needs do not give rise to institutions save in such rare cases as the Red Cross. There the need is really permanent but its geographical location fluctuates. An emergency may reveal a permanent need beyond local resources. Permanent organizations based on temporary needs or chance associations usually become sources of mischief.

Institutions as Agencies of Social Control

All these institutions either exercise power over the individual to secure the desired uniformity of conduct or delegate this power to some other, usually to the state. The source of this power and the justification for its use have given rise to endless discussions and many theories. No group is ever particularly worried over its own exercise of power but is often enraged when some other group ventures to deal with one of the members of the first. For our purposes it is sufficient to say that every child is born into some group and is brought up in accordance with its standards. The group forbids some things, permits others. These last become the rights of the individual and he likes to think of them as natural or God-given. Such is not their origin. My physical or mental powers are not given me by the group but my exercise of them is not left to my decision. I am accepted as a member in good standing so long as I obey its laws. If I refuse obedience and defy the laws I am liable to punishment. Civilized man can shift from one group to another more easily, perhaps, than could primitive man, but an isolated career is about as impossible for one as for the other. Since the individual cannot in real life follow the example of Robinson Crusoe it follows that he must abide by the decisions of some group, in appearance at least. Usually he does not debate this fact, nor study its causes. He finds it easier to conform than to protest. He observes a certain advantage to himself in social regulations as, for instance, in knowing on which side an approaching car will pass. He grumbles at the laws and is sure he could devise better ones, but he obeys, save where there is a clash of group morality. If a bachelor he may protest being taxed to maintain schools but if he studies the situation he finds that he gets indirect benefits. The net result is that unthinking loyalty to group standards is generally characteristic of mankind.

In as much as the group realizes that some matters are important and others trifling it draws a vague line between good manners and good morals. A man ought to know whether to drink coffee from the cup or the saucer; whether to use the knife or the fork in conveying pie to the mouth. Yet, no one considers him as anything but untrained and unrefined if he violates these conventions. Naturally the conventions vary from group to group.

Barring the defectives and the insane, criminals generally prove to be persons inadequately trained in group ideals and in whom some conflict of ideals has arisen. It is admitted that a great man might violate important standards through the acceptance of some new, and to him, higher ideal. In such cases when called before the bar of justice this type of criminal quietly accepts even extreme punishment without complaint, becoming a martyr for the sake of the future. Thus Socrates took the poisoned cup and Jesus the cross. In milder cases a new subgroup may be formed maintaining the essence of the old tradition but putting emphasis on some minor point or adding some ceremony about as important in itself as a new method of baptism, or laying on of hands, or washing of feet.

Considering the question from the other side, one of the most important and most difficult tasks undertaken by society is the proper selection of the rights to be granted individuals and of prohibition to be enacted. Historically, as von Ihering long ago pointed out, there has been a direct relationship between the general economic and social conditions and the crimes most severely punished.

> Every state punishes those crimes most severely which threaten its own peculiar conditions of existence, while it allows a moderation to prevail in regard to other crimes which, not infrequently, presents a very strong contrast to its severity as against the former. A theocracy brands blasphemy and idolatry as crimes deserving of death, while it looks on a boundary violation as a mere misdemeanor. (Mosaic Law). The agricultural state, on the other hand, visits the latter with the severest punishment. (Old Roman Law). The commercial state punishes most severely the uttering of false coin; the military state, insubordination and breach of official duty; the absolute state, high treason; the republic, the striving after regal power; and they all manifest a severity in these points which contrasts greatly with the manner in which they punish other crimes. In short, the reaction of the feeling of legal right, both of states and individuals, is most violent when they feel themselves threatened in the conditions of existence peculiar to them.[1]

Many illustrations of the truth of this thesis are easily found. One has but to recall our constitutional prohibition of the granting of hereditary titles; the violent reaction of the South against anything threatening the existing relationship of blacks and whites. Contrast the punishment meted out to the horse thief in western pioneer days with the attitude on the Isle of Man where this was a trifling offense compared to the theft of pigs or chickens. No one could take the horse off the little island but stolen pigs or chickens quickly lost their identity.

Institutions to Serve Human Needs

Everywhere on earth we find man trying to develop institutions which will enable him to utilize existing conditions to his greatest advantage and with the least friction with fellow man. If this be true, we shall not expect to find identical functions assigned to institutions in different parts of the world, nor will we be overconcerned as to the accuracy of the explanations man offers for his procedures. If, therefore, we had full knowledge of human history we should doubtless find much divergency in the development. The Hopi Indian of the arid Southwest, being an agriculturist, develops a snake dance equivalent in our history to a week's prayer for rain. It is not likely that the hunting and fishing Indians of Alaska, a country of excessive rainfall, will present a similar ceremony, but since they have the same need for food and clothing a comparable ceremony is likely. That is to say that, all men being fundamentally alike in their equipment and needs, certain culture patterns are sure to appear.

Much to our regret we know but little of this culture history, and most of our information concerns recent periods. It is more than an assumption that as each group has developed and the institutions have become better organized, professional classes have arisen, warriors, priests, medicine men, just as in our day government employees and teachers have increased. The advent of the professional man has produced certain obvious advantages in standardization of technique and, let us assume, certain improvements in methods. It has also introduced certain real, though less obvious, dangers. There comes to be an emphasis on creeds hitherto lacking.

Creeds are valuable as evidence of present positions, but they are easily if not invariably twisted into tests of fitness for membership, and the older they are the greater the halo of sanctity about them. The United States is about to elect a President, but few people are asking what man is best fitted to be President. Instead they ask what man the Democrats or Republicans will nominate, though not one voter in a thousand can tell what being a Democrat or Republican involves and that rare man is probably wrong. All are agreed that to elect a Socialist would be un-American. The point is that shibboleths have replaced reasons.

Given a group of men whose duty it is to keep the machinery going, who have a vested interest due to the source of their incomes, a situation is created in which the machine rather than the result is emphasized. Those in power dislike change both because man gets into ruts in his daily conduct, and because a change may bring about a shift in officials, a replacement by others. The result is that man tends to emphasize forms. He talks of the superiority of democracy to monarchy, of democracy for which the world is to be made safe rather than *through which* the world is to be made peaceful. How our fabled visitor from Mars must laugh at the spectacle of men shouting for democracy in politics and at the same time organizing religion and education on a basis of autocracy. Compare the Roman Catholics and the Quakers.

The truth of the matter is that the opportunity to exercise power is involved in all organizations dealing with great masses of men. It is *power* which calls forth man's ambitions. Yet history shows that few men have possessed unrestricted power for any length of time without exercising it for selfish ends. The fact that the man in power may be honest in his belief that he alone knows what is best and that God wants him to do his will in no wise minimizes the danger. The alliance of the bigot and God has been responsible for some of the worst episodes in history. Sincerity and despotism are often inseparable. Whether a man is inspired by God or possessed of a demon depends wholly on the viewpoint of the judge.

It is easy, also, for the administrative group to exalt the institution as an end in itself, and to subordinate the service to be rendered by the institution to the duty owed by the individual to the institution. This leads by easy steps to an emphasis on observance of forms rather than on the practice of virtues; on the letter rather than on the spirit. To take a common instance, church attendance as an example for the young. Why not regular attendance at primary schools to show belief in education; or at police courts to show an interest in justice? In reality the place to show whatever education or religion a man may have is in the conduct of his daily life. Usually only a very small part of any life is spent in direct contact with any given institution. The church is the product of the religious spirit, not its cause. Most education is secured outside of the school, for the school is the result of a desire for education, not its source.

Social Change

We started with the assumption that institutions were founded to meet human needs. It does not follow that any given form of institution actually meets them in adequate fashion. This may be due to the mistaken policies followed. Man's diagnosis of his troubles is seldom accurate.

His sociology contains more than a tinge of emotional bias. Insanity is not caused by moonlight nor cured by the casting out of devils. The sign of the cross and the recital of the text, "The word was made flesh," did not put storms to flight as Luther believed. In part man's programs depend on the accuracy of his analysis, but old superstitions die hard. Our newspapers still print columns of forecasts of careers based on the signs of the zodiac and the location of planets.

A greater source of error lies, probably, in the fact that change, not fixity, characterizes human affairs as well as organic life. The good becomes the enemy of the better. In a later chapter we shall endeavor to pay our respects to the great god Progress, hence certain facts may be omitted here. All that is now required is the statement that any change in underlying conditions of life must ultimately produce changes in social organization, possibly in social ideals and theory. In many ways the crystallization of institutions appears to be the most serious problem in their careers. It is so much easier to follow old methods than to experiment with new that man drifts along hiding the facts from himself until some social revolution seems to break down the very foundation of his society.

Man is so conscious of the evils of his own day, so little informed as to the actual problems of earlier times, that he is constantly bewailing the downfall of his institutions, the lack of faith of the present generation. If the analysis here presented is at all correct this attitude is unwarranted. So long as the needs continue there is no reason to question the continued existence of institutions. I have never seen any suggestion that in the future children will not need education. Society without schools of some sort is a contradiction of terms. The bolshevists of Russia did not destroy government, did not even destroy autocracy. All they did was to replace the Czar by Lenin. What the man who bewails the passing of some institution really reveals, in addition to his own ignorance, is the decay of some particular form of institution. All sorts of sects, religious, political, economic, have appeared, flourished, and passed. Unfortunately the existence of endowments often prevents the decent interment of social corpses so there is always a certain amount of stench in the air. We have no reason to believe that our pet cults will not follow the same road. Much as our emotions may be stirred our common sense tells us that *the form* is not of permanent importance.

We may see this more clearly if we remember that our ethical standards are in no sense final save as they are stated in theoretical fashion. Vice and virtue must ever be redefined in terms of present conditions. They cannot be stated in absolute terms unless we wish to disregard the truth. We say that sin is always wrong, but the real question is to determine whether a given act is sinful or not. It is by no means a foregone conclusion that the program of an institution at any given time is helping towards the realization of our ideals. Hence, the necessity of readjustment with all its attendant difficulties.

In the last analysis, then, the man best serving his fellows is not he who slavishly follows the forms of existing machinery but he who constantly strives for the realization of human ideals, using or modifying present machinery (*i. e.*, institutions) as may be best.

Once more we glimpse the physical basis in the background of all our efforts. When man found himself baffled in his search for happiness and prosperity on earth he shifted the emphasis in his religion to the methods of reaching heaven. When he felt himself gaining the mastery of the world, and saw in his own maladjustments the source of social ills, his religious spirit sought to express itself in social service. The spirit is the same, the form is changed. After all, is not the essence of religion to be found in "faith in the possibilities of human achievement"? The problems of social institutions are here, not hereafter.

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CHAPTER XVII

THE CONCEPT OF PROGRESS

> The more I think of it, I find this conclusion more impressed upon me, that the greatest thing a human soul ever does in this world is to see something. Hundreds of people can talk for one who can think, but thousands can think for one who can see. To see clearly is poetry, prophecy, and religion—all in one.—John Ruskin

Attempts at Definition

The Great God Progress

The most popular divinity of modern Western civilization is called Progress. At his shrine all do lip service. No infidelity is more heinous than the refusal to acknowledge his sway. It rarely occurs to any one to inquire into his history or nature. Yet in reality he is a newcomer in the pantheon of major divinities.

The ancient Greeks and Romans knew him not. To them cultures flowered and faded into chaos in endless cycles. The early Christian fathers had not heard of him. To them the end of all things was near at hand. The Lord might stop life at any time, salvaging into heaven the few souls known as the elect. Not until the sixteenth century in the writings of men like Bodin do we begin to get a picture of man striving ceaselessly forward toward a far-distant goal. The development of a picture of a golden age in the future was slow and difficult. All Europe looked back to a golden age in the past. The Bible was ancient. Jesus lived long ago. Socrates and Augustine were early teachers. The art of Phidias, the poetry of Homer were hoary with age. The glory of Rome had long since passed away. The Renaissance turned the thoughts of men back to the "wisdom of the ancestors."

Ideas of Middle Ages

Aristotle and Aquinas sought to reveal the purpose of God in nature.

> They read into the cause and goal of the universe that which alone justifies it for man, its service of the good. . . . Where they seem to go beyond the warrant of experience to the physics of to-day, is in interpreting the causes that actually produce change in the world on the analogy of human aspiration, and seeing all moving and living things as drawn onward by what may be said to be love for their unrealized ideals. To the modern scientist, who prefers to enumerate the successive steps in this process, the goal is uncertain and the force of love smacks of magic. But this faith that the world can not only be made to serve man's purposes, but actually does so, that things can not only be perfected, but that the whole course of nature draws towards perfection, was precisely what the Middle Ages meant by faith in God. . . . Which is to say, modern science is physics, while medieval science was something at once less potent and more important, ethics.[1]

To the men who shared Aristotle's belief that there was in nature an "inner, perfecting principle" it followed as a matter of course that the discovery of the facts would lead almost automatically towards a fuller realization of this perfection. The center of interest lay in the purpose of things. This science would reveal. Hence the enthusiastic belief of the end of the eighteenth century in education. But this hope was destined to be short lived. There is a limitation to science. As Pareto says, "Science can only connect one fact with another and hence must always stop at some fact. Human imagination would go further; it would reason about this last fact; would learn its cause and, if it cannot discover the real cause, will invent one."[2]

This difficulty calls our attention to the fact that facts alone do not satisfy man's emotional ends. Emotions rather than facts are the driving forces in our lives. We need not enter into the discussion of the problems involved, but, on the other hand, we must not forget them.

Various ideals have been, and are, held by men, at least, different names have been given to the ideals. This suggests that in all ages men have sought similar ends under different names. The emphasis on ways and means has varied. Now, with eyes ahead and hope high, we think we are traveling the road of progress. It is hardly claiming too much to say that the present faith is the creation of the industrial revolution which, in its turn, was the outgrowth of the vision of men like Roger Bacon who first appreciated experimental science. But what is progress?

What Is Progress?

Few words are more often used and less frequently defined. It appears to imply motion. Is it motion away from something or towards something? If the latter, how is the goal determined? Is it anything more than is suggested in the definition of a cynical friend, "Progress is the movement towards any goal considered desirable at any given time"? If this covers the case, progress to one man or group might be synonymous with retrogression in the mind of another.

Evidently there is a lack of clear thinking and definition of terms. To one man progress means evolution due to something inherent in human nature and society. Just what this quality is which makes for progress, he does not stop to inquire, nor has any one given us more information. To the next man, progress and evolution are but substitutes for the word history. Many men fall into the intellectual quicksands produced by the attempt to transfer organic laws to society. One of the greatest living biologists has warned us of this danger, J. A. Thomson of Aberdeen, *Perils of Biological Analogies*

> The fallacy of regarding sociology as no more than a recondite branch of biology is not merely verbal, implying differences of opinion on the tedious question of the best definition of these two sciences; it involves a misconception of what human society is, a misconception which is discredited by the facts of history and experience. No one doubts that the life of a social group is made up of a complex of activities of individual persons—but these are integrated, harmonized, and regulated in a manner as far beyond present *biological* analysis as the integration, harmonization and regulation of the chemical and physical processes in the individual organisms are at present beyond *mechanical* analysis. . . .
>
> To keep to the concept of selection for a moment; it was applied to plants and animals, it was illustrated, justified if not demonstrated and formulated; and now with the imprimatur of biology it comes back to sociology as a great law of life. That it is so we take for granted, but it is surely evident that in social affairs, from which it emanated as a suggestion of biology, it must be reverified and precisely tested. . . . In any case a formula borrowed from another science and applied to a new order of facts—even to those in which it first arose as a suggestion—must be rigorously tested. Otherwise, both organic and social sciences resolve themselves into socio-morphic illusions.[3]

We do not need to review the attempts of various writers to treat of society as an organism nor to consider critically the pictures of some of the ablest of them—say Spencer—who believed that society was evolving from a military to an industrial type in which the functions of government would be reduced to the minimum. Spencer has proved to be a poor prophet. A vast host of lesser men have fallen into the error of thinking that analogy is equivalent to evidence. Organic evolution has produced parasitism as well as independence. Can we apply the word progress to retrograde movements?

Criteria of Progress

In so far as the writer can see, there is no way of testing progress by subjective things like happiness or contentment. The pig in his wallow is as happy, so far as we can tell, as any man. Poverty and happiness are not incompatible, while wealth and happiness often appear as enemies. Nor can we tell whether savage man is better or worse than civilized man. Society, like the individual, can be measured only by the things it does, its achievements. It seems possible to suggest a classification of these achievements:

1. Increased knowledge
2. Increased wealth
3. Increased understanding of man himself
4. Broadening and extension of human programs
5. Refinement of social processes
6. Emphasis on social as well as personal virtues

PROGRESS MEASURED BY ACHIEVEMENT

Knowledge

The necessary basis of all achievement is knowledge of the physical universe. Without this man leads a hand to mouth existence wholly dependent on what nature furnishes.

The application of knowledge makes possible the production of wealth which is, as Thucydides suspected long ago, the material base of civilization. As already indicated, increased wealth makes possible rising standards of living. It may seem strange in these days of overemphasis on money that the rôle of wealth calls for special comment. Yet this is true. The mass of men is to-day so great and so many men are not directly employed in production, or are engaged in trade, that serious misunderstanding has arisen; hence the current philosophy that there is ample wealth if it were equitably distributed. Color is given to this belief by the fact of overproduction, as in agriculture. But it is wealth that makes possible the leisure that enables the poet to sing or the artist to create. Wealth allows man to work for distant goals—to visualize, plan and create tunnels and bridges, to erect sky-scrapers. That wealth may be abused and used in antisocial ways needs no demonstration.

Modern man likes to flatter himself by assuming that his mental processes are better than those of savage or primitive man. This is open to serious question. We have accumulated a great mass of facts which have been examined and compared until we have eliminated many earlier misunderstandings. This mass, still a blend of truth and fiction, is taught to the next generation and becomes its starting point. We all embody in our explanations the theories we have learned. No man is able, and no man has time, to demonstrate all the things he asserts as true. As Boas says:

> We are only too apt, however, to forget entirely the general, and for most of us purely traditional, theoretical basis which is the foundation of our reasoning, and to assume that the result of our reasoning is absolute truth. In this we commit the same error that is committed by all the less civilized peoples. . . . There is an undoubted tendency in the advance of civilization to eliminate traditional elements, and to get a clearer and clearer insight into the hypothetical basis of our reasoning. It is therefore not surprising, that with the advance of civilization, reasoning becomes more and more logical, not because each individual carries out his thought in a more logical manner, but because the traditional material which is handed down to each individual has been thought out and worked out more thoroughly and more carefully.[4]

We know more because we build on the foundations handed over to us by our predecessors.

"Man unlike the lower animals has had to be his own domesticator," wrote Bagehot. The process has been very slow and still is far from complete, but there has been a marked advance in the understanding of things human.

Traders and missionaries have spread the wares and ideas of culture centers to the tribes on the marginal areas of earth until all are dreaming of expansion and self-determination. A few great languages are so widely known that the effort to develop one world language is hardly necessary. There is little knowledge which is in any sense secret or even guarded. Man is beginning to talk in terms of a united world though he still plans and acts in smaller units. With wider contacts the exaggeration of local tenets is lessened and sympathy and understanding broadened. Brotherhood becomes a reality between kindred spirits even in countries temporarily hostile. Man's development is automatically breaking down artificial boundaries.

Refinement of Manners

There has come about a refinement of manners and of speech with the growth of civilization; at least, it seems to be true, for exact comparison with earlier standards is very difficult. Guts become intestines; legs twist into limbs; rebels are modified into confederates, to cite a few current examples. At times there seems to be danger that this refinement will be at the expense of virility, just as families of highest pedigree often have little else but pedigrees. The increasing group life is forcing the ruder individualists of north European stock to accept some of the courtesies characteristic of Spain and Japan.

Social Virtues

With these changes there is coming an emphasis on social virtues as well as on private. Even to-day the stock defense of a scoundrel in public life is that he is a *good* husband, a *kind* father, a *pillar* of the church. Some day we shall insist that a public official know his job and not care whether he is a Republican and a saint, or a Democrat and a sinner. We may even insist that an automobile mechanic know something of machinery. To condemn a man who steals five dollars and then praise a man who, though personally virtuous, allows the state to be fleeced, is idiocy. Private virtue is not enough. The situation calls for reanalysis.

To such things as have just been mentioned it is entirely proper to apply the term progress. If so, though the list may not be wholly complete or satisfactory, it includes about everything which can be suggested. Subjective mental attitudes are excluded. Concrete data on these matters are available and when "social scientists" stop gabbling about Plato and Spencer and tackle their real job it may prove possible to find ways of measuring and classifying the data, that is, to develop a real sociology, and not a philosophy of history.

Social Classifications

It can hardly have escaped the notice of the reader that the preferred basis of classification of human societies has been their chief method of getting a living. Such terms as hunters, fishers, farmers, and manufacturers are universally employed. These words are far more accurate and informing than savages, barbarians, and civilized. A strict definition of savage would enable us to employ the word but hitherto it has been impossible to secure such definitions. We must always ask just what a writer means by the term. The average man reads moral values into these terms; the savage is cruel or treacherous, for example. Ultimately we must come to technical terms in spite of this handicap. When we do it is evident that the three just cited will be inadequate to represent all levels of human culture. To call the Eskimo hunters and fishers is to give a fairly adequate notion of their status but to call the Americans civilized is meaningless. In reality the high spots of human development, called civilizations, have always been the places where wealth was aggregated and where, therefore, certain opportunities existed which were not found elsewhere. But, in these very areas social conditions may have been such as to bring about a speedy downfall of the culture. Historians have often been puzzled to explain why the period of highest culture of a people immediately preceded its decay. Our terms are clearly inadequate and their inadequacy is a good indication of our ignorance of facts.

The Course of Culture

Not long ago it was the fashion to assume that the human race had passed by gradual steps from such simple activities as fishing to such complicated processes as manufacturing, the route having been the same for all peoples, though some groups had stopped, or been stopped, at way stations, to remain behind and yet alive as "contemporaneous ancestors." While there is some truth in the statement, there is a large measure of error in the explanations to which it has given rise. Civilized man likes to assume a superiority over the savage, forgetting that he can demonstrate this superiority only so long as he remains in contact with his civilization. At every stage of culture a knowledge of certain facts and arts is necessary. The Indian boy of fourteen could have got a living where the European man of twenty-one would have starved. Break the civilized man's connection with his culture, transfer him to the environment of the Eskimo and he will perish long before he learns how to make a fire by rubbing sticks together, a trick known to every Eskimo boy. Transfer him to most tropical lands and he will perish from disease long before he learns any local remedies. If adopted by savages and *taught,* he may learn and survive. The reverse shift is equally hard for the savage. This is but the application of the plain meaning of earlier chapters. There is a correlation between culture and environment often forgotten by civilized man. The so-called savage is as well adapted to his life conditions as is the civilized man to his, and sudden transfer of one to the status of the other is almost equally fatal. Both situations call for all the brain power a man possesses.

Thus, it seems certain that whatever definition of culture we may agree on, we shall have to deal with two quite different but closely related things, achievement and social organization.

It has been shown that achievement is conditioned by the discovery of facts—knowledge. The use thereof is contingent on wealth. Gorgas could overcome certain diseases at Panama and dig the canal, but no hunting or even agricultural people on earth could afford so expensive a health program even though it knew just what might be accomplished. We too know how to do many things which are not feasible at present. The situation is far from being as simple as one might infer from the advice often given backward peoples.

Scientific Research

To begin with, few persons on earth spend much time in thinking. Constructive mental work is the hardest task ever undertaken by man. In view of the great importance of new knowledge it is a bit startling to realize that far less than 50,000 persons on earth are devoting themselves to pure science. This is not to suggest that valuable discoveries may not be made by other men, mariners for instance, or missionaries, or workmen in industry, though the discoveries of the last are likely to be improvements in machinery and processes. Nevertheless it does indicate that the group from which important new information is likely to come is very small. Hadley of Yale has been credited with the definition, "Culture is the opposite of absorption in the obvious." Research involves too many hours of diligent watching of events apparently insignificant, together with an appreciation of the meaning of little things, to be a popular pastime. The scientist is ever caricatured as a half-wit chasing rainbows of some sort. Yet to the scientific attitude we owe every step forward from the conditions of brute life. That a new attitude has come in certain industries marks a real change of sentiment.

"Ye shall know the truth and the truth shall make you free," whatever the speaker had in mind, is a profound observation. It is perhaps this very character which has led to the already mentioned antagonism of science and theology which so many people are trying to deny to-day. The habit of belief and the habit of criticism must ever be hostile. In reality man has ever been suspicious of new truth because of the possibility of some upset in accepted beliefs. In as much as man has ever tried to pose as an intelligent being, he is ever ready to deny the antagonism and to profess himself a disciple of fact rather than an adherent of tradition. He must, therefore, be judged by his actions rather than by his words.

Human Inconsistency

In all truth his actions have been very inconsistent. Researches whose possible results might confirm his old beliefs, increase his wealth or better satisfy some want, have been supported usually, but not always. We are quick to appreciate new articles for which we can see immediate use. The American Indian instantly cast covetous eyes on the horse of the Spaniards as well as on their guns and fire water. There is a tradition of a Minnesota Ojibway captured by his enemies the Sioux who was quickly honored as a god when they found a metal knife in his possession. The Indians remained hostile to the white man's concept of property and to most of his philosophy whose acceptance would have meant traveling the "white-man's road." In the white group itself not long ago there was violent antagonism to the introduction of iron plows, bathtubs, railroads, and automobiles which were called "devil-wagons." One dreads to think what would have happened to a man who suddenly appeared with a radio or telephone in the sixteenth century in Europe. The Jew still uses a stone knife in his sacred ceremonies. Tradition thus holds man to old customs, at times, even in the face of obvious advantages of new machines. What a multitude of opprobrious terms have been applied to the innovators introducing new wares!

To many researches no special antagonism has been shown because no one could imagine that the results would have any practical application to the affairs of ordinary life or to traditional beliefs. Not infrequently, however, enough intellectual dynamite has been accumulated in this way to cause considerable concern when it exploded.

In other cases every forward step has been made in the face of intense opposition. During the Middle Ages an anatomist was forced to study apes to learn how man was made, so convinced were the church authorities that the dissection of the human body was an act of impiety. In Andrew D. White's *Warfare of Science with Theology* (a great work though poorly organized), which is very reliable in spite of certain attacks made on it, the student will find almost endless illustrations of this conflict.

Really there is no need to turn to older books for such evidence. Plenty is to be found in the daily press. One has but to recall the "good" men and women who prefer to have mankind suffer from all the plagues than to allow experiments on animals. Consider the recent attempts of the mayors of Chicago and New York to have history rewritten according to their desires. Witness the foolish legislation as regards the doctrine of evolution. Our national heroes must not be portrayed as men. Average parents with children ready for college are much more eager to find "safe" schools where there are no "godless" or "socialistic" teachers than they are to put their children under men who are hunting for new truth. Children should be taught that the ideas of the parents are correct. Protestants do not read Catholic journals regularly nor do Republicans depend on Democratic sheets. Modernism is inspired by the devil. The average student wants to be told what to believe rather than be forced to think.

By contrast see Henry Ford riding into world-wide fame because his products give the ordinary man a new means of doing something he wants to do. So anxious are we to increase our wealth that in this country alone about a billion dollars are invested (?) each year in shyster concerns. According to popular verdicts the inventor who doesn't get rich is mentally lacking or socially foolish. A man like Babcock who might have become a millionaire is unknown by name, probably, to the majority of farmers who profit from his researches, and unknown almost certainly to him who chances to read this sentence.

It happens that we have had a century or more of remarkable advance in the study of nature and in the application of our discoveries in industry. That which we know is little compared with that which remains unknown. We have, however, no way of knowing that we can maintain the pace in centuries to come. We may reach the limit in any given direction at any time, just as the ancient suspicion of the existence of minute organism awaited the invention of the microscope for verification. No one can predict what use we may make of this new knowledge. The scientist already knows how to do many things which no group of people can afford to do. Whether we can ever do them cannot be predicted, for this depends on the production of wealth and the use to which it is put.

Thus we come to the second part, the rôle of social organization and social ideals, which we shall discuss a bit more in detail in a later chapter. Our experience seems to indicate that here we are to encounter our greatest difficulties. Given the opportunity, man appears able to wrest from nature more secrets than he is able to utilize. In recent centuries his achievements have outstripped his social organization and his social problems have grown apace.

Progress Is Not Inevitable

Progress, then, is far from inevitable. History teems with fallen cultures. We know little of the causes of their downfall. We observe that in all cases they were located in places where unusual wealth might be produced. They have been developed in various parts of earth, by various races, under varying systems of government and with diverse religious beliefs. Admitting the possibility that Huntington is correct in his claim that climatic change has been a constant factor—though positive evidence is lacking—and admitting the adequacy thereof if present, there remains the possibility that two other causes, at least, have been operative. The first we call overpopulation, so many people in a given area that adequate wealth cannot be produced. We know that this has played a part in history—how large a part we cannot tell. Wealth is not in sight for Italy with its present population.

Morals

There remains the possibility that the trouble has lain primarily in the social organization—the morals, to use common language. The moralist has ever insisted that the people were forsaking God, that is, were developing bad morals. But to the professional moralist most of the things done by man were bad, and, therefore, he became better as he stopped doing things until finally he stopped living and went to heaven, a place seemingly populated by people who had not done things on earth. "We are all miserable offenders and there is no health in us." This is a bit too naïve. Wealth has always been portrayed as antagonistic to conventional morality. Has this been due to the fact that the wealthy could do more things? At least it suggests the possibility that the trouble has been due not to the decay of morality but to its crystallization, to a failure to change to meet new conditions. This question needs more attention than has been given it.

Once more we return to earth. The conditions of society are based on the reactions of man to the physical basis. The earth is the starting point. No limit seems to be set to the use he can make of it, save the limit of his own capacity. No one can predict what use any given group will make, nor how adequate a social organization it will develop, nor whether its ideals will promote or check further advance. Man has progressed not by denying nature but by shaping it to his ends. Failure and success are equally possible. Which shall it be?

World Unity

A few paragraphs above it was suggested that the combination of science with the desire if not the necessity of using the products of all parts of earth, was forcing a world unity. Has the reader ever stopped to ask himself what this involves in terms of ideals and organization? If not let him map the parts of earth on which we call for our daily supplies and to which, directly or indirectly, we must send some of our products in exchange. Let him picture the great web of relations necessary to accomplish this and then speculate as to its reactions on our old theory of national isolation. The older concepts of well-being were not only local but involved an indifference as to what happened elsewhere. If human achievements are creating a world unity, will not a redefinition of the content of progress be necessary? How can any country maintain its standard of living without a guarantee of steady supply of necessities? Let those who advocate the end of war answer.

After Progress, What?

Nothing is more amusing than to travel about America and find every little hamlet anxious to become something it is not. The most common desire is for increase in population, as if size meant improvement. A little farming village wants industries started. Progress again! Is progress the only possible ideal of life? It has been indicated that such has not always been the case. We may well ask, After progress, what?

> In achieving its ascendency and unfolding its meaning, the Idea of Progress had to overcome a psychological obstacle which may be described as *the illusion of finality.*
>
> The illusion of finality is strong. The men of the Middle Ages would have found it hard to imagine that a time was not far off in which the Last Judgment would have ceased to arouse any emotional influence. . . .
>
> But if we accept the reasonings on which the dogma of Progress is based, must we not carry them to their full conclusion? In escaping from the illusion of finality, is it legitimate to exempt that dogma itself? Must not it, too, submit to its own negation of finality? . . .
>
> In other words, does not Progress itself suggest that its value as a doctrine is only relative, corresponding to a certain not very advanced stage of civilization; just as Providence in its day was an idea of relative value, corresponding to a stage somewhat less advanced? Or will it be said that this argument is merely a disconcerting trick of dialectic played under cover of the darkness in which the issue of the future is safely hidden by Horace's prudent god? [5]

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CHAPTER XVIII

THE COSTS OF CHANGE

We are all blind until we see
  That, in the human plan
Nothing is worth the making if
  It does not make the man;
Why build these cities glorious
  If man unbuilded goes?
In vain we build the world unless
  The builder also grows.
—EDWIN MARKHAM

Prosperity and Virtue

One of the deep-seated convictions of man, regardless of race, location, or era, has been his belief that society prospered to the degree that it followed implicitly the commands of God and practiced certain simple virtues. The things held as virtues have varied, but among our recent ancestors have included labor, thrift, temperance. Did serious trouble arise for the whole group or for the individual, the explanation was sought in some sin or moral defect originating in the heart of man. Here was the explanation of failure to succeed, shiftlessness or vice. All problems would be solved if the teachings of religion were obeyed.

Regardless of the amount of truth in this explanation, it is too simple to fit all the facts. Men do not differ so much about abstract ideals as about their application in daily life. How much must a man labor to avoid being considered lazy? How much must he save to be deemed thrifty? How much may he drink without being intemperate? On such points the verdicts vary. The first temperance society in Philadelphia of which I have knowledge pledged its members not to get drunk more than four times a year, listing the occasions on which it was permitted, such as New Year's Day. How would the temperance leaders of to-day describe such a pledge?

Change as a Source of Social Problems

Ascribe to any given set of virtues what merits we may, it seems certain that changes in the conditions of life and the necessary readjustments constitute an important, perhaps the most important, source of social problems. There are many possible causes of these changes; the gradual drying up of parts of Asia as described by Huntington, the migration to the New World, movements from cold to hot lands or from moist to arid regions, are sure to put a stress on old customs. Too long have we talked of the world in terms of static conditions. In reality it is ever changing, though centuries may have to pass ere man accepts the fact.

Man himself is responsible for many of the changes. The world is one thing when man knows not the metals; it is very different when he has learned to use copper and iron. To all intents and purposes the physical environment varies with the stage of intellectual development of man. The many discoveries and inventions suggested in earlier chapters have not only modified our daily life but have produced and are producing profound changes in our attitudes, many of which are far from being appreciated at present.

To use the happy phrase of Ogburn, there is a "cultural lag." Slow as the discoveries seem to have been in most periods of history, the social readjustments they involve are even slower. The result is that when there comes a period of rapid change such as that through which we are passing, the evidences of maladjustment are multiplied. This is a thesis whose general truth or falsity should be revealed by a brief survey of American history.

Changing American Conditions

At the very start we should recall that the early white settlers, while coming from a few closely related stocks of Europe, brought along a lot of prejudices and jealousies, so that many present social dividing lines are of foreign origin. Arrived here all faced the necessity of settling a wooded wilderness so far removed from Old World trade centers that frontier life involved many hardships. Contrasts based on local conditions soon appear. Stony New England led to a village life, to the town as the unit of government. The rugged coast line with many harbors, with its nearness to the fishing banks, and with abundance of water power, stimulated the development of fishing, of maritime industries, of manufacture and commerce. In the middle states, as in southeastern Pennsylvania, with richer and more level agricultural lands there soon appeared veritable garden spots tilled by the various German Anabaptist groups. The southern states with a climate rather enervating to the white man of northern Europe solved the problem by importing Negro slaves. Few of the Europeans of the day, or their American children, had any special antipathy to slavery as such, as is evidenced by the slave plantation conducted in the Barbados by an English missionary society. Even the Pennsylvania Quakers owned some slaves. Slavery, however, did not pay in the North, so soon died out. It did not pay in the mountain parts of the South and never really secured a foothold there. It did pay in the lowlands. By the end of the eighteenth century all the great Virginia leaders at the time of the Constitutional Convention of 1787 believed that slavery was nearing its end. But a combination of certain then underpopulated regions (South Carolina and Georgia) with certain northern maritime districts (Rhode Island and Connecticut) brought about the famous compromises with reference to the Negro in the Constitution. Then came the invention of the cotton gin by a Yankee tutor which made possible the growing of short-staple cotton on a commercial scale. The world got a new and valuable fiber for its clothing but slavery received a new lease of life. Soon adherents of the same religion began to draw from their one inspired Bible quite contrary teachings as to slavery, depending on their residence. The antislavery movement of the South died out with the development of northern abolitionism. The rivalry between the slave states and the free states began, the southern domination in national affairs was broken and finally there came the Civil War which marked the end of the era of a confederation of sovereign states and the beginning of the nation.

Local Contrasts

Slavery is but the most notable illustration of that conflict of local interests so common in our history. These clearly reveal the close connection between life conditions and our standards and ideals.

As time went on the imported religious antagonisms were modified. Boston lost its fear of the "free-thinkers" of Rhode Island and a citizen of Providence might walk its streets unescorted. The Quakers lost their bad reputation and steadily rose in public esteem until the general verdict agreed with that of Trader Horn, "The Quakers, Ma'am, I've always held to be above par," while the title of old Thomas Underhill's book, *Hell Broke Loose, or a History of the Quakers both Old and New,* evokes an incredulous smile. Gradually the Philadelphia papers ceased to complain of the incoming Germans of whom they spoke at the middle of the eighteenth century in the very terms they used a century later with reference to the "Hunkies" of the coal regions. The Papists of Maryland worked out a *modus vivendi* with the Church of England folks. A spirit of tolerance arose and America was to be a place of refuge for all the socially or spiritually oppressed of Europe.

The Alleghenies are crossed and the frontier is pushed further and further from the ocean. West, too, to the land beyond the Missouri where no white man can prosper, are sent the Indians. The Middle West begins to worry about the French control of the Mississippi, the only outlet for its grain. Jefferson nullifies, at least outsteps, the Constitution by making the Louisiana purchase and the size of the country is doubled. Expansion was overlooked by the Constitution makers. Westward push the sons of Virginia as well as New York. The Mississippi is crossed and the land-hungry Germans, Swedes and Norwegians help in settling the prairies of the Northwest. The Conestoga wagons which carried the produce of Lancaster to the Philadelphia market reappear as "prairie schooners" en route to the semi-arid plains, bearing the label "Kansas or Bust" on the way out, and only too often the legend "Kansas and Busted" on their return. By 1900 the Pacific coast is settled and what is perhaps the most important event in American history has occurred—the exhaustion of free land and the disappearance of the frontier.

Long before the western trek had ended, certain changes were evident in the older sections. The influx of Middle West farm products was driving the agriculturist off the less productive eastern areas save where some special crop could be grown. But this slack in agriculture was more than made up by the development of industry. Soon industry needed more workers than could be supplied locally. The distance of free western land, the growing equalization of conditions in eastern America and western Europe, together with the improvement in transportation facilities, caused a cessation of immigration from earlier European centers and started a wave from eastern Europe where standards were lower. This newer group found its opportunity in the industrial centers of the East. Having good sense they settled where they could earn a living instead of going where later American moralists said they should have gone, into the already overdeveloped farming regions.

City versus Farm Life

The modern industrial city developed and the results were much the same whether its population was made up of rural Americans or rural Europeans. Concentration of population was the result of the use of power-driven machinery. But the gathering of hordes of human beings in small areas forced changes in methods and conditions of life. A mere list of these would fill a volume so we must be content with a few specimens; the contrast of the farm and city home may suffice.

The farm family occupies a separate house, and in its care and in the care of the soil the diversity of work is so great and the amount so large that there is occupation for every member, young or old. About all the food, and at first much of the clothing and household supplies, are produced on the place. The water comes from the well, the milk from the cow. The air is pure, the nights are quiet. All neighbors are known for miles around. Cash is scarce as money is little used. The doctor, preacher and storekeeper are old friends. Coöperation in times of extra work is the rule.

How different is the life of the city family! The house becomes the place where one sleeps, for industry has gone to the factory and with it the workers. The city life makes necessary common supplies of milk and water. Food is bought for daily needs. The bakery replaces the kitchen. The streets become the playgrounds for children. Incessant noise, day and night, fills the air. Smoke and dust pollute it. The neighbors are replaced by strangers to whom one seldom speaks even though the enforced intimacy of street car and subway turn all into human sardines. Everything is put on a cash basis.

Evidently daily life must vary widely with such contrasts between city and country. The city makes possible the expansion of the fine arts, of the opera, theater and library. It calls to itself the most expert and best-trained professional men of all sorts. It turns night into day. Are these advantages or dangers?

Wealth

Beyond question modern industry has tremendously increased the production of wealth. This is true even in agriculture. It has taken work out of the house of the farmer as well as out of the city house. It has likewise produced some realignments in social matters which are far from simple. For instance, it has created a wide gap between the owners and managers of industry and the workers. The old farmer and his hired man associated and coöperated. Too often the wage-earner and the employer have been pitted against each other as if their interests were divergent. Industry has resembled warfare rather than coöperation. What share of the return from industry should go to labor? What bitter tirades one hears against selfish owners! On the other hand, who has heard of the wage-earners discussing what they ought to return to a losing industry? This is rare, is it not? Industry has created a social gulf as well, for now employer and laborer belong to almost wholly separated social groups, including often separate political parties. There are solutions, no doubt, to these labor questions. Their genesis is all that concerns us here.

Industry

With the factory has come a sharpening of the problems of poverty. Our forefathers boasted that beggars were unknown in America. The present cost of caring for the unfortunate is appalling, partly because we try to care for them. Modern industry requires more efficient workers despite a popular belief to the contrary. Inefficiency shows itself more quickly and its results are more serious. The inefficient got along somehow in older days. Now he becomes a handicap to the others. Men are not alike. The demand for equality in distribution indicates a faulty analysis of the situation. Wealth does mean power and selfish use of power is dangerous. Are the questions simple?

Factory life, office life, is indoor life compared to farming. Indoor life in heated, often overheated, rooms with a reduction in the amount of physical exertion, with less pure air and less sunshine, involves greater exposure to the attacks of certain diseases. This is the key to the ravages of tuberculosis. Tuberculosis gets us because we live indoors, pneumonia when we leave the factory. Typhoid lurks in milk and water, especially when we use our rivers as sewers. The incidence of disease is changed and we must change or suffer. We cannot use either alcohol or beefsteak as did our ancestors without paying a penalty.

Taxation

As farmers we paid for the government by taxes on lands. There was logic in the old system, there is little but opportunism in our present jumble, which does not deserve to be called a system, of taxation. Modern industry has tremendously complicated the problem of government and increased its functions, so we tax everything in sight. The old landowner often became rich in spite of what he did to the land because the growth of population raised the price of land. Much of present taxation seems a scheme to penalize industry and thrift rather than to stimulate and subsidize it as claimed.

The Home

As already stated, modern life has minimized the rôle of the home and with it that of the family. Once the unit in industry was the family, now it is the individual. One does not get paid as the head of a family. The bachelor gets the same wage as the father of ten children. Then, too, we have divorced our social life from the house. We entertain at hotel or club; we seek amusement in moving pictures; we get our food from the delicatessen store. Home remains as the place to which we go when all else is closed or when sleep becomes imperative. The effects on the family life have not gone unnoticed. Only in the country districts does the family function much as it did. Save the victrola and the radio, all modern inventions have pulled us from home.

In this summary we have touched upon a series of problems familiar to every intelligent person. Our social programs, machinery, adjustments, call them what you will, have not kept pace with the changes. We have felt, acted and then bewailed, rejoiced, or cursed according to our temperaments, rather than deliberated as to the readjustments we ought to make.

Suggested Remedies for Social Maladjustments

The speaker states the problem and throws the subject open to discussion. Up jumps some enthusiast with a remedy. Hear his solution of the problems raised. For the evils of capitalism adopt any one of the fifty-seven varieties of anarchy, communism or socialism and all will be well. Human nature will change, that is, the nature of the capitalist, for it is obvious that no laborer would graft on another. The lamb will lie down beside, not within, the tiger. For the vexing questions of taxation adopt single tax. Absorb the "unearned increment" and all land speculation will stop and all governments be free from financial worries. In matters of health accept Christian Science, fathered by Quimby and mothered by Eddy, and get rid of these modern demons, the doctors. In family matters stop divorce, the root of all troubles. Compel folks to live together whether they want to or not and everybody will be happy. All these remedies can be secured in convenient and nicely wrapped packages with full instructions as to use and with as many recommendations and endorsements as Peruna or Sanatogen ever had and given by equally competent experts. How simple, but alas, how misleading!

Without debating the amount of good any of these remedies may contain (there was whiskey in Peruna and cottage cheese in Sanatogen) their fundamental weakness is that they are panaceas. No human program can be perfect. Every conceivable institution has its weak points. Adopt any form of socialism you will, put it in full force, and the day following repair will be needed, that is, unless all human experience is misleading. Until the experiment is tried one cannot tell whether there will be improvement or the opposite.

After the patent medicine man has been quieted (active verb) the revivalist will arise to recommend a return to the good old standards of grandpa's day. The word revivalist has been too much limited in its application to religion. The revivalist is found in all fields. The good old-time religion will revive the churches. A return to "constitutional ideals" such as majority rule will eliminate political wrongs. City problems may be solved by a return to country life. These are samples of the recommendations we hear daily.

Can We Go Back?

These likewise have a radical defect. Society can no more go back to earlier conditions than a man can forget all he knows and start again in the kindergarten at the age of seventy. Once man has created a new world, the old has ceased to be. A given individual may escape to the wilderness; a society, never.

A dilemma presents itself. Changes, call them improvements or anything else, in the conditions of life, introduce problems, witness the automobile. We want the new things but we dislike to face the consequences. These we call the costs of change. According to our natures we divide into groups, or, and more correctly, we face one way on one problem and the other on the next, for we are never logical.

The Reactionary Attitude

Personify these attitudes into reactionary and radical, under both of which there are several species. The reactionary comes, typically, from a group successful under older conditions. He is prosperous and eminent. He is satisfied that the adherence to old standards, plus (Grace to God) superior ability, has put him where he is. He dislikes all these modern innovations. Associating with his own group he hears similar sentiments at church and club. He feels that the man who differs is dangerous, "not safe" he calls him. Seeing the advantages of the old order he fears the dangers involved in change. According to the intensity of his feelings we call him, conservative, revivalist, reactionary.

The Radical Attitude

Opposed to him is the radical. As a rule he comes from a group which has little to lose and much to gain, perhaps, from a change. If he comes from an old successful group, as he does at times just as "actresses happen in the best regulated families," he is likely to be known for the warmth of his feelings rather than for the depth of his intellect. He recognizes that things are not working well and believes in some readjustment. If mild in nature we may dub him a reformer, if rabid he is a red or bolshevist or whatever the popular title may be just as the French peasant to-day often calls his donkey Mussolini. Sometimes he wants reform, sometimes advocates change, on general principles for its own sake.

Change Is Dangerous

The truth is found, as usual, somewhere between these two extreme positions. There must have been merit in the old institutions else they could not have survived so long. There *are* values, cultural and other, in old standards. Change *does* involve danger. Education *is* dangerous. Once in a while students do change their minds and cast off old beliefs. Change may involve the displacing of an old group with no obvious immediate improvement—as in Russia to-day. The individual who espouses the new cause may be lost just like the mariner who sails the unknown sea, or the aviator who ventures over trackless oceans.

The Way Out

Yet, change is inevitable. There is no escape. Man may refuse to make new inventions, may live for a time in secluded mountain valleys or desert oases, but sooner or later the outsider with new machines, new ideas, enters the Paradise, and Adam eats the apple even if later he throws the blame on his wife. That no man can save himself has long been an accepted religious maxim. That no people can save itself is equally true. Only by denying that trait which makes him a man, his intellect, can change be stopped. Readjustment is difficult. New policies do not always succeed; new machines do not always work. There is no merit in change as such. Society has no escape. It must pay the penalty for being what it is. Panaceas do not exist either in medicine or politics. Man must work out his adjustment to an actual world, that is here and now. The attempt to go back means not retrogression but decay. Society must test out the new programs, holding to those that work, discarding the others no matter how antique or how new.

> The old order changeth, yielding place to new,
> And God fulfills himself in many ways
> Lest one good custom should corrupt the world.

CHAPTER XIX

THE SPREAD OF CULTURE

"In harmony with nature"? Restless fool,
Who with such heat dost preach what were to thee,
When true, the last impossibility,—
To be like Nature strong, like Nature cool!
Know, man hath all which Nature hath, but more,
And in that *more* lie all his hopes of good.
Nature is cruel, man is sick of blood;
Nature is stubborn, man would fain adore;
Nature is fickle, man hath need of rest;
Nature forgives no debt, and fears no grave;
Man would be mild, and with safe conscience blest.
Man must begin, know this, where Nature ends;
Nature and man can never be fast friends.
Fool, if thou canst not pass her, rest her slave.
—MATTHEW ARNOLD

Throughout this volume the attention of the reader has been directed not to the wonders of the physical universe but to the background of human activity. However unsuccessful he may have been, the author has sought to trace the development of man as related to the rest of the world. This has involved, naturally, some consideration of the growth of man's own understanding of things and of his own organization. The beginnings of man's culture are too deeply buried in the débris of history for us to see them. The very location of the most primitive cultures is uncertain and we have little idea of the arts of the Heidelberg man and no idea of his thoughts.

When dawn comes in human history we find small groups of men already in possession of certain arts and simple tools. Had they developed these ere they left their original home sites to start the long journey to the ends of the earth? If not, have the various groups made similar inventions as they reached the various stages of culture, or has the original invention of some genius been adopted first by his group and then spread to the others? Here is an extremely perplexing and important question whose answer would throw much light on history. Much is still in doubt, yet we are greatly indebted to the cultural anthropologists of the last generation and it is to be expected that they will make even greater contributions in the future.

Culture Diffusion

It seems settled that a given culture radiates from the center in which it arises. The older traits or products are likely to be found at the extremities of this radiation rather than in the old center where newer forms have been devised. This assumes, of course, that the center itself has not been moved. The statement holds even to-day in spite of the fact that modern methods of commerce and transportation enable a given style to encompass the earth in a short time. Telephones and automobiles are most common in the United States. In more primitive times the spread of any article must have been relatively slow.

It is entirely conceivable that wholly separated culture centers might have had a parallel development leading to the invention of similar devices in corresponding stages. In actual life, so far as we know, this has seldom happened. History records many instances of borrowing, very few of separate invention. So common has this borrowing habit been that the discovery of similar tools or traits always raises the suspicion of some hidden association. The copper axes of certain Indian tribes so closely resembled those of ancient Egypt that competent students have insisted that the Indians had worked on Egyptian models. There is not a scrap of evidence for this interpretation. The Maya Indians of Yucatan developed a calendar vastly more accurate than any known in the Old World for another thousand years. They had an excellent system of notation, based on 20 rather than on 10, and had invented a zero sign, by the time of Christ. The Romans had no such sign and their system was cumbersome; M equaled 1,000, but to write 1928 required many letters, MCMXXVIII. Our zero sign was invented by a Hindu sometime between the sixth and ninth centuries. Here is a case of parallelism, independent invention.

Our alphabet is an excellent illustration of diffusion. We know that it was in use east of the Mediterranean by 1000 B.C. and recent discoveries have pushed it back possibly another millennium. As used by the Semites it contained no vowel signs. These were introduced by the Greeks who transformed some of the older breath and stop characters into vowels. Thus the Semitic *vau* (a sort of *F*) becomes *upsilon* and is put at the end of the alphabet, having a value of *U* or *V*. The vowel sound corresponded to the French pronunciation of *U*, hence the French name, *Y-grec*. The Romans could not represent this sound by *U* so introduced the *Y*. In time *U* and *V* come to represent different sounds so *W* is introduced into the English of the eleventh century. We distinguish between *J* and *I* but the useless dot over the small *j* shows its origin. Our letters have become pure symbols but their earlier names were taken from common objects: A=alpha=aleph=ox; B=beta=beth=house; G=gamma=gimel=camel. Thus an old device, modified to suit local needs, has lasted for ages and has spread over the earth. The Chinese and the Japanese use written characters in common but pronounce the words so differently that they cannot understand each other. The arch was invented but once (in India) so far as we know. The Arabic notation is almost universally followed.

It appears, then, that man's intellectual devices, as well as his domestic plants and animals, have spread from certain original centers. It is easier to copy than to invent or rediscover. The most advanced peoples appear to have been (and to be) those in a position to borrow the most. The significance of this statement in relation to the problem of culture development should be noted.

Culture Absorption

Roughly speaking, the American Indians when the white man came here were about as far along the road to modern culture as were the north Europeans when Tacitus wrote his *Germania*. The culture of maize had spread from Central America to New York and it was cultivated in hills rather than sown broadcast as were the grains of Europe. In the birch-bark canoe they had the finest craft made by primitive men, but most of the Indians had no access to birch trees and the skin-covered tubs in which the Sioux crossed the rivers were like the coracles of old England. In the snowshoes the Indians surpassed any similar invention of the white man. In the arid Southwest they cultivated thousands of acres by irrigation ere the white man had learned to rotate his crops. Though the Indians in favored regions were using copper they were really in the new stone age. They had no domestic animals comparable to the horse, cow and pig nor were there any such in the New World. Their houses equaled those of Europe.

Europeans

The north European had just entered the age of metals but the use of metals as well as most of the domestic animals had been developed to the southeast. In these regards and in these only were they ahead of the Indians and no tribes of north Europe equaled the Mayas and Incas. But the former had the inestimable advantage of having advanced neighbors to the south, neighbors reaching out to the wilderness to further their own interests but, in so doing, introducing the arts of civilization to the northern barbarians. It is not an accident that the southern coast of France developed long before the northern part of the country. From the older centers the barbarian became familiar with the use of metals and for centuries he continued his borrowing habits. He took over the art of writing. He based his jurisprudence on Rome. He absorbed the mathematics of the Arabs. He accepted the combination of Judaic-Neoplatonic philosophy as his religion, and finally he rediscovered the art and literature of Greece.

The basis of a large part of what we to-day call Western culture was not developed at home but was taken over almost bodily from other peoples. History tells us that this absorption was a long, slow, and often painful process. It indicates that the barbarian had the capacity to develop, a capacity already shown by his relatives who had pushed into Italy under the name of "longbeards" or into Spain as Visigoths. It shows also that all cultures depend in large measure on the work of predecessors, often of other races. So-called civilized man may borrow readily from primitive man, as the adoption of the culture of maize or potato by the whites, and the enthusiastic reception of the tobacco complex indicate. It is worthy of note that the white man took over not only the grain, corn, but almost the entire set of traits going with them.

It matters not whether current or later verdicts approve or disapprove what is borrowed. The Indian's liking for the white man's "fire water" is comparable to the later use of opium by the whites. Whenever any group finds anything it wants, whether useful or harmful, it tries to obtain it. This attitude has characterized all peoples of whom we have knowledge.

Civilization a World Product

In a sense all civilization is a world product. The old attempts to explain it in terms of race are inadequate for they but magnify the difficulty of explaining why some of the present "superior races" have been so tardy in manifesting their qualities. History seems to give us a picture of one favored region after another beginning to develop but limited in its development by the degree of contact with older culture centers as well as by its natural resources. Solomon sent abroad for precious wares. The Roman galleys sought tin in Cornwall, the Portuguese fleets sought India, the royal adventurers of England combed the seas, all driven by the same motive. No great culture center remains willingly self-sufficient, nor can any modern center remain isolated. Granted that China may build a wall, or Japan adopt a policy of isolation, the ultimate result is certain.

Thus trade arises to bring the products of the wilderness to the center, or to exchange the silks and tea of China for the manufactures of Europe. It is often said that the trade routes of earth should run north and south that the products of different zones might be exchanged. There is some truth in this but it is far from being the whole truth. The metals show no zonal distribution and metals have been increasingly important. What we see is trade between culture centers and relatively undeveloped areas, between fur-producing districts and densely populated lands, between manufacturing and agricultural regions.

Culture Centers

In older days the great culture centers were very few in number at any given time and one might dominate the known world as did Rome. After an earlier period of slow penetration by migrating tribes taking possession of the land and driving earlier groups ahead of them, a process found all over earth at different periods, we enter a period of conquest where the desire is to make other areas pay tribute. A period of what is essentially slavery arises and this still lingers in certain modern theories and in the so-called "contract-labor" still used by some countries. But the situation changes. International slavery became as unprofitable as domestic slavery. No home country can long guarantee colonial welfare. The German colonies in Africa became expensive luxuries, always were for that matter. This is true of some of the island dependencies of both England and the United States. That further changes are ahead is evident.

A greater change, however, is the synchronous development of a few great powers in different parts of earth. North Europe has what is essentially one standard civilization, weakened by unfortunate racial, political, linguistic differences, handicapped by three vermiform appendices, Spain, Italy and Turkey, likely to cause trouble at any time, harassed by an enormous bear continually growling on its eastern flank, and is struggling to pay the debts brought on by her own policies. In the Far East a great giant is awakening from the sleep of ages and is finding difficulty in converting a family government into a nation. Japan, highly developed and alert, is conscious of her inadequate national wealth and is casting longing eyes on Manchuria. South Africa and South America are yet to develop to adult stature. There remains North America, uniform in language and general ideals, united in so far as the rest of the world is concerned. The power which America is to exercise during the next century is evident. How that power is exercised, and to what ends, are matters of world concern.

In this book we have been trying to get a bird's-eye view of all these matters and to discover how much or how little we understand what is going on. No one can suggest that the present world situation was clearly foreseen a century ago. Who then would have dreamed what Japan was to accomplish? Who of our constitutional fathers or contemporary Europeans visualized the growth in America? Answer, not one.

If, however, we ask ourselves how it has come about, there are a multitude of ready answers. The answer of the Mohammedan, "The Will of Allah," is as close an approximation to the truth as any. In other words it has resulted from the application of man's intelligence to the problem of getting a living.

There is in this no suggestion of the writer's personal verdict as to whether the situation is good or bad, hopeful or discouraging. We are but seeking to present the facts on which our judgments must rest.

The Progress of Science

The break from the intellectual attitude of ancient Europe, foreshadowed by the suggestions of the twelfth and thirteenth centuries, culminated in the science of the eighteenth. Man was to be saved by science, not by faith. The world was a perfect creation, full of plan and purpose, headed for some glorious goal. Only man was vile, interfering with nature. Hence the emphasis of Rousseau on the necessity of a return to a state of nature. So Pope sang in his *Essay on Man*:

All are but parts of one stupendous whole,
Whose body Nature is, and God the soul; . . .
All Nature is but Art, unknown to thee,
All chance, direction, which thou canst not see;
All discord, harmony not understood:
All partial evil, universal good:
And, spite of pride, in erring reason's spite,
One truth is clear, whatever is, is right.

But a different note is struck by Tennyson despite his faith in things ultimate:

Ah me, for why is all around us here
As if some lesser God had made the world,
And had not force to shape it as he would?

Science had brought and is still bringing an understanding of the physical world hardly dreamed of by the greatest men of earlier times. It brought also in its train, the greatest intellectual upheaval the world has ever known. Out of the window went one hoary belief after another. The more we know of matter the more wonderful and mysterious it becomes. The same is true of living things. The doubt of the adequacy of old explanations reaches to man himself.

At no time known to us has the gulf between the information of the specialist and the man on the street been so great. They live in different worlds. Obviously this is a dangerous situation for it stimulates the ignorant man of faith to stir the people to action on a matter of which he knows nothing, like Bryan on evolution. So great is present knowledge that the specialist in one field can hardly understand the language of an expert in another subject. What genius is to make a new synthesis and create a picture on which the world can look and say, I understand, or believe? What system of education is to bridge the gulf?

Research

No one can predict what man is yet to discover or invent. I am told that the head of our patent office sometime prior to 1850 recommended the closing of the office as all useful inventions had been made, and a little later the head of the agricultural machinery section declared that nothing more could be hoped for in the way of harvesting machinery, yet this was before the invention of the binder. I, myself, have heard learned proofs of the impossibility of heavier-than-air flying machines. Vastly more remains to be learned than we have discovered. This will require the concentrated efforts of trained men, such as the corps of specialists maintained by the electrical companies. The problems are too great, and too costly, for individual students. Who is to pay the cost when, in nine cases out of ten, long and expensive research gives no useful results, save as negative results are useful? If we say the government, how shall we convince the people already restive under the ever growing cost of modern government? These are but a few of the questions involved.

In many ways vastly more important is the determination of the use to be made of this new knowledge. Shall it be used for the benefit of some one group, or made available to the world? Shall we emphasize poison gas and explosives used to destroy men by hundreds instead of singly as in older wars? Shall we use it constructively or destructively? Either answer is possible. Shall we say, stop research, man knows enough of evil now? Further tasting of the tree of knowledge may bring new curses on us, that is true. The uselessness of new information is stressed every time a trip to the South Pole is suggested.

Nature and Man

These questions are stated to start an argument, not to settle one. The problem is social not physical. Nature is what it is. Man did not make it. He can study nature. He has shown great willingness to derive personal profit from what he has learned. Is there any reason to doubt that he may continue to profit in the future? Nature will not lead him to make wise, constructive use of her secrets. Man is opening a Pandora's box. The result will turn on human ideals, will it not?

Man is more than a beast. Civilized man is less bestial than were his primitive ancestors. He has created a new world but not by isolating himself on an island like Robinson Crusoe, nor by contemplating the universe from a pedestal like Simeon Stylites. Is he big enough to manage the new world he has created or must he think of himself in terms of Robot and Frankenstein's monster? Can man grow with his creations? That is the question for the future.

> Man as yet is being made, and ere the
>   crowning Age of ages,
> Shall not aeon after aeon pass
>   and touch him into shape?

SUGGESTED READINGS

The following books have been carefully selected. All are valuable though nontechnical in character. No one person will read them all but every library should contain some of them. The few books which have been starred are of outstanding merit and will give a good general knowledge of the field. The advanced student should know the French and German works listed. The figures in parentheses indicate the chapters of this book to which they have special application. In most cases, of course, they cover the topics of several chapters. As a rule the later books should be chosen but a few older works of historic interest have been included. For instance, one who wishes to know something about evolution should begin with any of the more recent works rather than with Darwin's *Origin of Species,* important as this is. If one wants to get acquainted with Darwin let him start with the little essay on earthworms.

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NAME AND SOURCE INDEX

(*q* after name means quoted)

Abbott, C. G., 28, 29; *q.* 623*f.*
Acosta, J., 275
Adam, 371, 476
Agassiz, L., 282, 379
Albucasis, 204
Alexander the Great, 160
Amati, 346
Ammon, O., 388
Andrews, R. C., 110; *q.* 106
Andry, N., 206
Antonius, O., 153, 154, 155, 158, 160, 177; *q.* 158
Aquinas, St. Thomas, 276, 450
Aristotle, 450; *q.* 30
Arlett, A. H., 396
Arnold, M., *q.* 478
Arrhenius, S. A., 28, 183, 201; *q.* 9, 12, 14, 184, 186
Audubon, J. J., 120
Augustine, 275, 276, 449
Avenzoar, 204
Avicennes, 204

Babcock, S. M., 461
Baber, R. E., 264
Bach, W., 346
Bacon, Francis, 276
Bacon, Roger, 451
Baer, K. E. von, 280
Bagehot, W., *q.* 454
Bailey, P., 331, 355
Baker, O. E., 247, 266. *See* Finch and Baker.
Balfour, A., 66
Balzac, H. de, 16, 389
Barker, *q.* 295
Barrell, J., 6, 17, 27, 28; *q.* 6, 19
Bassi, R., 208
Bateson, W., 321, 326; *q.* 298
Bean, R. B., 392*ff.*, 407
Bede, 271
Beebe, W., 60
Beethoven, L. von, 346, 389
Bell, A. G., 197
Bell, W. B., 123, 138*f.*, 148
Beneden, E. van, 297
Bertillon, J., 420, 434
Bessemer, H., 185
Bingham, W. van D., 395
Biological Survey, Bulletin, *q.* 116, 135
Birch, R. S., 236; *q.* 234
Björnsen, B., 389
Blumenbach, J. F., 378*f.*
Boaz, F., 389, 407, 464; *q.* 390, 454
Bond, H. M., 394, 407
Boyle, R., 10
Bragg, W., 15, 28; *q.* 14*f.*
Brown, R., 296
Brown-Sequard, C. E., 313
Bryan, W. J., 486
Buffon, G. L. L., 277*f.*, 378
Burckhard, 366
Burns, R., *q.* 111
Bury, J. B., *q.* 464

Butt, N. I. *See* Harris and Butt.

Cain, 62
Calmet, Dom, 277
Carroll, J., 217
Carr-Saunders, A. M., 355
Castle, W. E., 322; *q.* 319
Cattell, J. McK., 344, 434; *q.* 425
Cavendish, H., 10
Celsus, 204
Cesnola, 284
Chamberlain, H. S., 388
Chamberlin, T. C., 5
Chambers, R., 280
Chancel, G. C. B., 191
Chapin, F. S., 293; *q.* 285
Chapline, W. R., 266
Chatterton-Hill, G., 434
Chinese Classic, *The Great Learning*, *q.* 435
Chinese Trimetrical Classic, *q.* 375
Clark, A., 110, 148; *q.* 102*f.*, 105*f.*, 142
Clarke, F. W., 28; *q.* 8
Clodd, E., 293
Cohn, 208
Conklin, E. G., 355; *q.* 321, 324
Copernicus, 4
Corey, H., 236; *q.* 220
Correns, C., 300, 303
Crum, F. S., 419
Curie, M. S., and T., 10
Cuvier, G., 274, 279, 282, 379

Dalton, J., 10
Darwin, C., 70, 91, 96, 97, 152*f.*, 164, 272, 277, 280*ff.*, 286, 289, 293, 301, 306, 314, 320, 427; *q.* 280
Darwin, E., 278*f.*; *q.* 278
Davenport, C. B., 285, 336, 356
da Vinci, L., 195, 205, 274
Davis, M. L., 84; *q.* 77
Davy, H., 193, 228
De Candolle, A., 177; *q.* 167, 168
Delafond, H. M. O., 208
Derrick, S. M., 397
Descartes, R., 276
De Vries, H., 300*f.*
Dexter, E. G., 84; *q.* 76
Diodorus, 154
Dixon, R. B., 400, 406, 407; *q.* 385*f.*
Doll, E., 396
Dorsey, G. A., 374
Drummond, H., 110, 411, 433; *q.* 96
Dublin, L. I., 264, 416
Dujardin, F., 296

East, E. M., 243*ff.*, 266, 331; *q.* 246, 261
Eberth, C. J., 224
Ecclesiasticus, *q.* 371
Eddy, M. B., 474
Edison, T., 192, 197, 351
Elkington, 65
Ellis, H., 344, 356, 368, 374; *q.* 363*f.*, 365
Empedocles, 3
Encyclopædia Britannica, 166; *q.* 271
Eve, 371
Everman, B. W. *See* Jordan and Everman.

Faraday, M., 184
Ferguson, G. O., 396
Finch, V. C., and Baker, O. E., 152, 177
Finlay, C., 217
Fisk, E. L., 431, 434; *q.* 432

Fiske, J., 281
Florists' Review, 148; *q.* 130
Flynt, J., 414
Forbush, E. H., 119, 148
Ford, H., 461
Francis of Assisi, 389
Franklin, B., 195, 196, 242
Fraser, W. J., 266; *q.* 252
Frederick the Great, 348
Freeman, F. M., 397
Freud, S., 370
Fuller, T., *q.* 323
Fulton, R., 195

Galen, 205
Galileo, 4, 271
Galton, F., 320, 344, 351, 418
Garruth, W. H., *q.* 269
Geddes, P., 358
Gegenbauer, K., 296
Gobineau, A. de, 388
Goddard, H. H., 330*f.*, 333, 335, 355
Godkin, W., 266; *q.* 242
Goethe, J. W., 276, 389
Goff, J. C. *See* Holmes and Goff.
Goodyear, C., 173
Gorgas, W. C., 217, 220, 236, 458; *q.* 221, 222
Grant, M., 388
Gray, A., 281
Gray, L. C., 266
Great Elector, The, 348
Gregg, J. E., 398*f.*, 407; *q.* 399
Gregory, J. W., 65*f.*, 84
Gross, J., 304
Gustavus III, 348
Guyer, M. F., 327, 329, 355, 356, 429, 434; *q.* 337*ff.*, 339*f.*, 340*f.*

Hadley, A. T., *q.* 458
Haeckel, E., 281*f.*
Haldane, J. B. S., 37
Hall, G. S., 396
Ham, 379
Hankins, F. H., 407
Hann, J., 60; *q.* 48, 55, 77
Harets ben Kaladah, 204
Harris, F. S., and Butt, N. I., 201; *q.* 185*f.*, 193*f.*
Hartley, G. I., 147, 148; *q.* 125
Harvey, W., 205, 296
Hastings, W., 363*f.*
Hellpach, W., 77
Helmholtz, H. von, 389
Henderson, L. J., 39, 60; *q.* 37
Hero, 195
Herodotus, 95, 203
Herskovitz, M. J., 398, 407
Herter, C. A., 110; *q.* 92
Hertz, F., 389, 407
Hill, J. A., 419*f.*, 434
Hipparchus, 3, 4
Hippocrates, 204
Hoffman, F. L., 429
Holland, W. J., 148; *q.* 127, 145
Holmes, S. J., and Goff, J. C., *q.* 360*f.*
Homer, 449
Hooke, R., 296
Hooker, J., 280
Hoover, H. C., 244
Horn, Trader, 468
Hornaday, W. T., 121, 141, 148
Howard, L. O., 110, *q.* 103
Hrdlicka, A., 402*f.*, 407
Hubble, E. P., 5
Hunt, S. B., 392, 394, 407
Hunter, J., 378
Huntington, E., 81*f.*, 84, 245, 266; *q.* 66*f.*, 76*f.*, 83
Huntington, E., and Williams, F. E., 84, 236, 255, 266; *q.* 79*ff.*, 82*f.*, 224

Huxley, T. H., 97, 281*f.*, 379
Hyde, Dr., 423

Ibsen, H., 389
Information Service, 395*f.*, 407
Ireland, A., 344

Japhet, 379
Jefferson, T., 469
Jehring, R. von, 448; *q.* 442
Jenner, E., 213
Jennings, H. S., 321, 322; *q.* 309*ff.*, 318*f.*
Jesus, 442, 449
Job, 202
Johannsen, W., 10
Johnson, R. H. *See* Popenoe and Johnson.
Johnston, H. H., 407; *q.* 401
Joly, J., 6
Jordan, D. S., 332
Jordan, D. S., and Everman, B. W., 99, 110; *q.* 100
J. Am. M. Ass., 433; *q.* 413
Judaeus, Isaac, 204
Justinian, 165

Kammerer, P., 313
Kant, I., 276, 379, 389
Keen, W. W., 215, 230, 236
Keith, A., 60; *q.* 37*f.*, 40*f.*
Keller, C., 153, 177; *q.* 160, 161
Keller, H. G., 397
Kellogg, Vernon L., 284, 293; *q.* 282*f.*
Kendall, A. I., 110; *q.* 92
Koch, R., 209*f.*
Kropotkin, P., 110, 427; *q.* 109

Lamarck, J. B., 272, 279*f.*
Langdon-Davies, J., 374; *q.* 371*f.*
Lantz, D. E., 148; *q.* 139*f.*
Laplace, M. de, 5, 389
Laveran, C. L. A., 221
Lawrence, T. E., 117
Lazear, J. W., 217
Leeuwenhoek, A. von, 87
Leibnitz, G. W. von, 276, 379
Lenin, N., 446
Leocohier, D. D., 266; *q.* 255
Lessing, G. E., 276
Libby, W., 221, 229, 236; *q.* 203, 204
Life Extension Institute, Bulletin, 434; *q.* 431
Linnæus, C., 206, 270, 272, 276*f.*, 282, 377
Lister, J., 229
London, Jack, 414
Lotka, A. J., 419, 433
Lucretius, 178
Lull, R. S., 28, 60, 110, 293; *q.* 32*ff.*, 94*f.*, 99
Luther, M., 389, 446; *q.* 373*f.*
Lyell, C., 280, 281

MacIver, R. M., 433; *q.* 416, 418, 436
Maine, H., 373
Mallet, T., 110; *q.* 106*f.*
Malthus, T., 242*f.*, 263, 281
Mann, L., 266; *q.* 262
Manson, P., 217
Marggraf, A., 172
Markham, E., *q.* 465
Marochner, F. J., 266
Mason, O. T., 84; *q.* 78
Masters, E. L., *q.* 357
Matthew, P., 280
Mayo, E., 236; *q.* 227
Meckel, J. F., 280
Mendel, G., 301*ff.*, 306, 308*ff.*
Merriam, C. H., 60; *q.* 50*f.*
Metchnikoff, E., 92

Metropolitan Life Insurance Company, Statistical Bulletin, 236; *q.* 231
Michelangelo, 389
Milius, 275
Milliken, R. A., 28
Montague, Lady, 213
Montesquieu, B. de, 242
Moore, B., 29, 60; *q.* 16*f.*, 32, 36, 59*f.*
Moore, E. C., 293; *q.* 285
More, T., 242
Morgan, T. H., 308, 312, 321, 322, 360, 374; *q.* 307*ff.*
Morse, S., 197
Morton, W. T. G., 228
Mozart, 346
Murillo, 346
Mussolini, B., 475
Myerson, A., 356; *q.* 337*f.*, 351, 353

Nägeli, C., 302
Nat. Acad. Sci. Biog. Mem., 407; *q.* 395
Newcomer, T., 195
Newman, Col., 97
Noah, 379
Noguchi, H., 220, 221
Nystrom, 389

Odin, A., *q.* 351
Oersted, H. C., 196
Ogburn, W. F., 466
Oliver, T., 374, 433; *q.* 366*f.*, 412*f.*
O'Malley, A., 434; *q.* 420*f.*
Opportunity, 407; *q.* 397
Origen, 271
Osborn, H. F., 32, 60, 293; *q.* 48*f.*
Osler, W., 236; *q.* 222
Papin, D., 195
Parè, A., 205
Pareto, V., 464; *q.* 450
Parsons, F. G., 389, 407
Pasteur, L., 207*ff.*, 229
Pearl, R., 238, 263, 266, 321; *q.* 265, 316, 317
Pearson, K., 320, 326, 328, 355, 407; *q.* 345, 393*f.*
Penn, W., 213
Penna. Div. of Zoöl. Bull., 148
Peterson, J., 396
Phidias, 449
Pickering, E. C., 18
Pierce, Prof., 86
Pintner, R., 397
Pittard, E., 389, 407; *q.* 388
Plato, 456
Ploss, H., 374; *q.* 366
Polo, Marco, 192, 197, 272
Polybius, *q.* 415
Pope, A., *q.* 202, 485
Popenoe, P., 352, 356, 423, 434
Popenoe, P., and Johnson, R. H., 419, 434
Poulton, E. B., 284
Presser, 396
Pressey, S. L., 344
Priestley, J., 10
Ptolemy, 4
Punnett, R. C., 331
Pyle, W. H., 396

Quetelet, A., 320
Quimby, P., 474

Ralston, R., 344
Rameses the Great, 180
Ramsay, W., 10
Randall, J. H., 464; *q.* 450
Ray, J., 276
Reade, C., vi

Redi, F., 207
Reed, W., 217
Reibmayer, A., 428, 434
Reid, G. A., 426
Rembrandt, H. von R., 389
Reuter, F., 389
Rhazes, 204
Riley, W., 205, 236, 271, 293
Ripley, W. Z., 406, 407; *q.* 387*f.*
Rockefeller Foundation, *Review for 1926,* 220, 236
Roosevelt, Theodore, 110; *q.* 104
Ross, R., 221
Ross, E. A., 264
Rossiter, W. D., 37, 266
Rousseau, J. J., 389, 485
Rush, B., 217
Ruskin, J., *q.* 449
Rutherford, E., 13

Sage, Mrs. R., 145
St. Hilaire, G., 301
St. Paul, 275
Saunders, E. R., 284
Savery, T., 195
Sayer, N. E., 332
Schaeffer, A. N., 236; *q.* 216
Schallmayer, W., 417*f.*, 428, 429, 433, 434
Schamberg, J. F., 215
Scheele, K. W., 10
Scheidt, W., 407
Schelling, F. W. J. von, 276
Schleiden, M. W., 296
Schopenhauer, A., 389
Schubert, F. P., 389
Schuchert, C., 29; *q.* 21, 25*f.*, 27
Schumann, R., 389
Schwann, T., 296
Semper, K., 60; *q.* 57
Semple, E. C., 84; *q.* 70
Shelford, V. E., 60, 110; *q.* 53, 57*f.*, 102
Shem, 379
Shepard, W., 266
Si-Ling, Empress, 165
Simpson, J., 236; *q.* 229
Slosson, E. E., 201; *q.* 183, 189, 190
Smith, F. G., 148
Smith, J. B., 110, 148; *q.* 100, 101*f.*, 127*f.*
Smith, J. R., 260*f.*, 266
Smith, O. C., 341
Smithson. Inst. Rep., 110; *q.* 108
Socrates, 442, 449
Solomon, 483
Somerset, E., 195
Spallanzani, 207
Spencer, H., 282, 452, 456
Stevenson, G., 195
Stockard, C. R., 321; *q.* 316*f.*
Strong, R. P., 228
Strothers, F., 132, 148
Sunne, Dagne, 397
Swift, J., *q.* 85
Symington, W., 195

Taylor, A. E., 252, 266; *q.* 250*f.*
Taylor, G., 84, 381, 407; *q.* 67, 405
Taylor, H. S., 13
Tennyson, A., *q.* 485
Terman, L. M., 343, 356, 396; *q.* 341*f.*
Tertullian, 423
Teter, 396
Theognis, *q.* 237
Thomas, W. I., 374; *q.* 365*f.*, 369
Thomson, J. A., 110, 293, 451, 464; *q.* 91, 96*f.*, 284*f.*, 452
Thorndyke, E. L., 396
Thorpe, M. R., 60; *q.* 46

Thorwaldsen, 346
Thucydides, 453
Tiberius, 165
Titian, 346
Todd, W., 394
Tower, W. L., 316
Trabue, M. R., 396
Traub, M., 95
Tredgold, A. F., 355, 356; *q.* 329*f.*, 331*f.*, 332, 340, 353
Tryon, F. G., and Mann, L., 266; *q.* 262
Tschermak, E., 300

Underhill, T., 468
U. S. Dep. Agric., *Bulletin*, 148, 266; *q.* 134*f.*, 253*f.*
U. S. Dep. Agric., *Circular*, 235, 236
U. S. Dep. Agric., *Farmers' Bulletin*, 136*ff.*, 148
U. S. Dep. Agric., *Yearbooks*, 139, 148, 247, 266; *q.* 243, 247*ff.*, 251, 253, 254, 256*ff.*
U. S. Live Stock Sanitary Association, *Proceedings*, 235, 236

Van Dyck, H., 346
VanLeewen, W. D., 110; *q.* 95*f.*
Vespasian, 165
Virchow, H., 306
Virgil, 167; *q.* 151
Volta, A., 196
Voltaire, F. M. A., 389

Walker, F. A., 264
Walker, J., 191
Wallace, A. R., 280*f.*, 427
Ward, L. F., 356; *q.* 350*f.*
Wasmann, P. E., 108
Watt, J., 195
Weeks, D. F., 340*f.*
Weismann, A., 306*f.*, 313
Welsbach, A. von, 192
Wertz, B. O., 266
Wheeler, W. M., 148; *q.* 145*f.*
Whetham, W. C. D., 356
Whewell, W., 282
White, A. D., 293, 460
Whitney, M., 29; *q.* 22
Wiggam, A. E., 343*f.*, 356
Willcox, W., 264
William the Silent, 348
William III, 348
Williams, Bishop, 271
Williams, F. E., 84. *See also* Huntington, E., and Williams, F. E.
Wilmarth, A. W., *q.* 338
Winge, H., 324*f.*
Woehler, W., 39
Wolff, C. F., 296
Wood, L., 214
Woodruff, C. W., 84; *q.* 64
Woodruff, L. L., 99
Woods, F. A., 344, 356; *q.* 346*ff.*, 349, 351
Wordsworth, W., *q.* 61
Wright, H., 266

Yeoung, K., 397
Young, D., 391, 407; *q.* 392*f.*
Younghusband, F. E., 41

Zenophanes, 274
Zon, R., 266

SUBJECT INDEX

Ability, specific and general, 345. *See also* Intelligence; Genius; Race; Sex.
Abortion, 423*f.*
Accidents, 413
Acetylene, 192
Acne, 210*f.*
Acquired characters. *See* Heredity.
Adaptation, 40, 55*ff.* *See also* Man.
Agave, 175
Agriculture, 254*f.* *See also* Domestic plants; Domestic animals; Food; Land.
Air, 15, 23, 54. *See also* Altitude; Wind.
Albino, 326
Alcohol, epilepsy and, 341; heredity and, 316*f.;* in tropics, 66*f.;* selective influence of, 426; suicide and, 429
Alfalfa, 90, 137, 139, 168
Algæ, beginning of life and, 32*f.;* in repopulation of devastated area, 95*f.;* microörganisms and, 88; symbiosis and, 94
Alloy. *See* Elements; Metals.
Almond, 167
Alphabet, 480
Alpine race, 384
Altitude, 40*ff.*
Aluminum, 8, 9, 181*ff.*, 186*f.*, 194
American, racial characters of, 402*f.;* typical boy, 406
Ammonia, 35, 90
Amœba, 94, 291
Amphibians, 292
Amputations, 229
Anabolism, 365*ff.*
Analogy, biological, 451*f.*
Anatomy, comparative, 287*ff.*
Anemia, 230
Anesthetics, 228
Angel fish, 52
Aniline dyes, 296*f.*
Animals, adaptation to environment, 56*ff.;* aquatic, food relations of, 101; destruction of, 120*ff.;* distribution of, 48*ff.;* domestication of, 113, 122; effects of destruction of, 141, 144; food habits of, 103*f.;* food required by, 88*ff.;* in geologic time, 292; protection of domestic, 123*ff.;* services to plants, 96*ff.* *See also* Birds; Plant and animal associations; Nature, balance of; Domestic animals; Reptiles.
Antelope, 106, 107, 115, 120
Anthrax, 208, 209, 235
Anthropoids, 288
Antimony, 180
Antiseptics, 228*ff.*
Ants, Argentine, 132; association

among, 105, 108; influence on soil, 91; man's struggle with, 146
Ape, 277, 288*f.*
Aphids, 108
Apple, 168
Apricot, 167
Apteryx, 276, 292
Argon, 11, 15, 23
Ark, Noah's, 271*f.*, 275*f.*
Arsenic, 186, 230
Artichoke, Jerusalem, 168
Artifacts, primitive, 178*ff.*
Asiatics, climatic adaptation of, 63*ff.*; racial characters of, 377*ff.*
Aspen, 51
Ass, 106, 151*f.*, 155, 277
Association, between different forms of life, 93*ff.*; in struggle for existence, 105*ff.*; social life of insects, 145*f.* *See also* Mutual aid; Institutions; Society.
Astronomy, 3*ff.*
Atmosphere, 17*f.* *See also* Air.
Atoms, 10*ff.*, 30
Auk, 119
Aurochs, 153*f.*

Baboon, 288
Bacteria, beginning of life and, 32*f.*; chemistry of, 90; classified by foods, 88; discovery of, 207*ff.*; in digestive system, 91*f.*; in early explanations of disease, 206; killed by sunlight, 53, 101; nature and distribution of, 45*f.*; nitrogen-fixing, 33; pathogenic, 210*ff.*; possible utilization of, 176*f.*; respond to stimuli, 55*f.*; size and reproduction of, 87; temperature and, 51
Badger, 115, 139
Balance of nature. *See* Nature; Life.
Balsam, 132
Banana, 167, 169*f.*
Barberry, 103, 233*f.*
Barium, 8
Barley, 253
Barnacles, 133
Barracuda, 52
Bass, 99, 102
Beans, soil fertility and, 90
Bear, 114, 115, 123
Beaver, 115, 120
Bedbug, 132
Bees, 105, 165, 359*f.*
Beet, 139
Beet sugar, 172, 253
Beetles, damage to pines, 132; eaten by birds, 137; Japanese, 129*f.*, 142; ladybird, 131; potato, 128, 316; varieties on St. Helena, 289
Begonia, 296
Beriberi, 240
Beryllium, 11
Birds, destruction of, 118*ff.*, 140*ff.*; domesticated, 162*ff.*; food habits of, 104, 134*ff.*; list of extinct, 147; protection of, 144*f.*; reptiles and, 275; services to man, 133*ff.*
Biological analogies, 451*f.*
Biometrics, 320*f.*
Birth control, 263, 265, 424*f.*
Birth rate among women in industry, 412*f.*; declining, 415*ff.*; differential, 416*f.*, 419*ff.*; in United States, 264*f.* *See also* Sterility.

Bismuth, 181, 188

Bison, 107, 115, 121*f.*, 272

Black death. *See* Bubonic plague.

Black snake, 118

Blackbird, 120, 136, 137

Bleeders, 329. *See also* Hæmophilia.

Bleeding heart, 174

Blindness, 328

Blister beetle, 101

Blood, bacteria in, 206; circulation of, 205; crocodile, 205; sex differences in, 365; tests of relationship, 289

Blue fish, 100

Blueberries, 168

Bluebird, 134, 137

Bobcat, 123

Bobolink, 120, 136

Bobwhite, 119, 135, 137

Body, human, 34, 35, 69*f.*, 364

Boils, 211

Bone, 38*f.*, 179

Boron, 11

Bow and arrow, 178*f.*

Brachydactilism, 326

Brain, Negro, 392*ff.*; race and, 382*ff.*; sex differences in, 367*f.*; size, 289

Brant, 107

Brass, 180, 186

Bread fruit, 167

Breeding, science of. *See* Eugenics; Genetics; Selection.

Brick, 262

Bronze, 179*f.*, 186

Bubonic plague, 143, 227

Buffalo, 59, 151, 154

Bullfinch, 359

Bullheads, 102

Bumblebees, 96*f.*, 108

Bunting, black-throated, 59

Butterflies, 54, 132, 284*f.*, 291

Cabbage, 167

Cacao, 168

Cadmium, 181

Caisson disease, 41

Calcium, 7*ff.*, 11, 90, 186

Camas, poison, 50

Camel, 151, 156, 161

Cancer, 231

Canon law, 371

Carabao, 151

Carbohydrates, 37

Carbon, 6*f.*, 8, 11*f.*, 36*f.*, 90, 184, 186, 365

Carbon dioxide, 18, 37, 56, 58, 90

Carbonic acid, 23, 36*f.*

Caribou, 106*f.*, 159

Carnations, 174

Carrots, 139

Cassava, 168, 170

Caste, 406, 427*f.*

Castration, 359

Cat, 97, 143, 160*f.*, 235, 311

Catbird, 134, 137

Caterpillars, 137

Cattle, diseases of, 225*f.*, 234*f.*; early history of, 153*f.*; hybrids, 272; milk and butter fat production, 252; mutants, 311; number of, 151*f.*, 250, 263; snow and, 50; Texas fever and, 98

Caucasian. *See* White race.

Celibacy, 422*f.*

Cell, 33*f.*, 290, 295*ff.*, 361. *See also* Heredity; Sex.

Cenozoic age, animals of, 292

Cephalic index. *See* Race, criteria of.

Cereals, 167*ff.*

Cerium, 191

Chaulmoogra oil, 230
Cheese, 176
Cherry, 167
Chestnut, 143, 260, 297
Chicken, alcoholized, 316*f.;* blue Andalusian, 303; diseases of, 208, 209, 234; history of, 163; natural selection and, 285; sex linkage in, 312; Spanish, 303*f.;* varieties of, 272. *See also* Poultry.
Chickenpox, 426
Child, economic importance of, 416
Childlessness, 423. *See also* Sterility.
Chimney swift, 58
Chimpanzee, 288*f.*
Chinch bug, 132*f.*
Chlorine, 8, 11*f.*
Chlorophyl, 32, 53*f.*, 88
Cholera, 98, 227; chicken, 208, 209; Asiatic, 209; hog, 234
Chorea, Huntington's, 329
Christianity, influence on status of women, 371*f.*
Chromium, 11, 22, 181, 184*f.*, 189
Chromosome, 297*f.*, 360, 362
Church, celibacy and, 422*f.*
Cinchona, 173*f.*
Civilization, as self-destructive, Chap, XV; as world product, 482*f. See also* Culture.
Climate, 41*ff.*, 50; changes in, 82*f.;* civilization and, 78*ff.*, 81*f.;* disease and, 212; mental activity and, 76*f.*
Clouds, 44*f.*
Clover, 97, 168
Coal, 182, 192*ff.*, 262
Cobalt, 189
Cocoa, 174
Cockle, 126
Cockroach, 53, 132
Coconut, 167
Cod, 52, 98
Coffee, 167, 174
Cola, 174
Colloids, 32
Coloration, protective, 284*f.*
Color blindness, 325*f.*
Comets, 5
Commensalism, 93*ff.*
Commerce and geographic influences, 74*f.*
Competition. *See* Existence, struggle for.
Complexity, law of, 16*f.*, 31
Contraception. *See* Birth control.
Coöperation. *See* Association.
Coot, 59, 119
Copper, 7, 8, 21*f.*, 179*f.*, 182, 186*f.*
Copperhead, 117
Coral, 53
Coral snake, 117
Cormorant, 119, 162
Corn, 54, 58, 168, 169, 260
Corn borer, 129
Cotton, 126, 128*f.*, 167, 170*f.*, 255*f.*
Cottonwood, 54
Cowpox, 213
Coyote, 107, 114, 123
Crabs, 134, 291
Cranberries, 168
Crane, 115, 119
Crayfish, 102, 134
Creation, as past event, 17; theories of, 270*ff. See also* Evolution; Spontaneous generation.
Creeds, 444
Crickets, 127
Crime, 429, 441*ff.*

Crocodile blood, 205
Crocus, 174
Cro-Magnon man, 383
Crops, limit to variety of, 260*f.*
Crow, 107, 124, 136, 139, 140, 144
Cuckoo, 137
Cuckoo bees, 108
Culture, diffusion of, 479*ff.*; early, 62, 168*ff.*; influenced by physical factors, 71*ff.*, 78*ff.*; invention and, 182; stages of, 456; tendency to self-destruction, 111*ff.*
Curlew, 119
Currant, 168, 232

Daffodils, 144
Daisies, 126
Dandelion, 126
Darwinism. *See* Evolution, biological.
Date palm, 96, 167
Deafness, 328
Death rate, 264*f.*; birth rate and, 421; changes in, 231*f.*; in tropics, 65*ff.*; influenced by sex, 360*f.*
Deer, 50, 115, 121*f.*, 235
Dengue, 67
Deserts and rainfall, 48
Determiner, 299. *See also* Heredity, mechanism of.
Devastated areas, repopulation of, 95*f.*
Diamond, 14
Dinaric race, 384
Dingo, 160
Diphtheria, 231, 317*f.*
Disease, conquest of, Chap. VIII; geographical distribution of, 212; Koch's postulates, 210; suggested causes of, 206; tropics and, 66*f.* *See* specific names.
Docks, 126
Dog, 124, 159*f.*, 235, 278
Dogwood, 175
Domestic animals, 151-166, 253*f.*
Domestic institutions, 438*f.* *See also* Family.
Domestic plants, 166-167
Dove, 120, 135, 142, 286
Drawings, early cliff, 179
Drosophila, 309, 312, 324
Drugs, plant sources of, 173*f.*
Duck, 52, 59, 115, 118, 119, 162, 272
Duckbill, 276, 292
Dwarfs, 327*f.*
Dust, 19, 56*f.*, 413

Eagle, bald, 116
Earth, as center of the universe, 4, 271; structure and history of, Chap. I.
Earthquake, 20
Ebers papyrus, 203
Echidna, 292
Economic institutions, 438*f.*; in relation to social problems, 471*f.*
Educational institutions, 440
Eel, 273
Egret, 119
Electricity, atom and, 12*f.*; discoveries and inventions, 196*f.*; for illumination, 191*f.*; hydrogen ion and, 13
Electrons, 12
Elektron, 180
Elements, chemical, history of discovery, number, etc., 6-10; compounds of, 15*ff.*; found in

organisms, 31*ff.;* periodic table of, 11

Elephant, 122, 151, 157, 269, 289

Elk, 115

Embryo, 290*f.*, 299, 317

Emotions, 77*f.*, 359, 451, 467

Enamel, 186

Endocrine glands. *See* Glands, ductless.

Energy and climate, 79*ff.*

Engines, 182, 194, 195

Environment, achievement and, 343*ff.;* biological influence of, 279*f.;* changes in, 58; control of, 40; control of social, 430*ff.;* fitness of, 39; heredity and, 310*f.*, 315*ff.;* ideas and, 78; physical, 40*ff.;* urban *v.* rural, 470. *See also* Geographic environment.

Epilepsy, 205, 324, 333, 336, 337, 340*f.*, 429

Erosion, 20

Ethics, 447. *See also* Morals.

Eucalyptus, 175

Eugenics, 351*ff.*

Europeans. *See* White race.

Evolution, biological, Chap. X; Darwin and, 280-286; early bases of theory, 269-280; evidence on, 286-293

Existence, struggle for, Chap. IV

Eye, 38*f.*, 317, 411*f.*, 431

Eye color, 324*f.*, 377*ff.*

Family, 372*ff.*, 473. *See also* Marriage; Birth rate; Domestic institutions.

Fats, 33, 37

Feeble-mindedness, 324, 329*ff.*

Female. *See* Sex.

Fermentation, 208. *See also* Yeast.

Fern, 95*f.*, 290

Fig, 97, 167

Finches, 135

Fire, 10, 190*ff.*

Fish, commensalism and, 94*f.;* depletion of, 115*f.;* distribution and adaptation, 52, 53, 56; in ladder of life, 292; increased use of, 261; life cycle of tapeworm and, 211

Flax, 170, 176

Fleas, 95, 143, 211, 228

Flicker, 273

Fluke, 102*f.*, 211

Fluorine, 8, 11*f.*

Fluted scale, 131

Fly, 53, 98, 142, 143, 225, 298

Fog, 48

Food, as check on increase of life, 99*f.;* comparative production of, 253*f.;* depletion of, 115*f.*, 119, 122*ff.;* exports and imports of, 255*f.;* new sources of, 260*f.;* United States supply, 250*ff.;* world requirements, 243*ff.*

Forest, area in United States, 249, 251; increased rainfall and, 49; resources, 256*ff.*

Formalism, 444*f.*

Fossils, interpretations of, 273*f.*

Four-o'-clocks, 303

Fox, 115, 120, 121, 124, 160

Frog, 278, 292, 297

Fuel, 192*ff.*, 257*ff.*, 262

Fundamentalists, 276

Fungus, 88, 94, 143, 233, 234

Furnace, 194*f.*

Gall-midge, 105*f.*, 132

Garter snake, 118
Gas, as fuel, 191
Gasoline, 198
Gayule, 173
Gemmules, 282*f.*, 314
Gene, 299, 307*ff.*, 360. *See also* Heredity, mechanism of.
Generation, spontaneous, 32, 278
Genetics, 291
Genius, 324, 341*ff.*, 369
Geographic environment, distribution of life and, 275*f.*, 290; in American history, 467*f.*; influence on man, Chap. III. *See also* Environment.
Geological time-table, 25*ff.*
Germ cell. *See* Cell.
Germ theory of disease, 209*ff.* *See also* Bacteria.
Germicides, 228
Gibbon, 288
Gila monster, 117
Ginkgo, 167
Gladiolus, 174
Glanders, 235
Glands, ductless, 38, 359, 363; feeble-mindedness and, 332
Glass, 199
Goat, 151*f.*, 157, 235
Gold, 7, 10, 21*f.*, 179*ff.*
Gonorrhea, 315, 423
Goose, 52, 59, 115, 162, 272
Gooseberry, 168, 233
Gopher, 91, 138
Gorilla, 106, 289
Gourd, 167
Grape, 132, 234, 311
Grass, 126, 168
Grasshopper, 101, 127*f.*, 137, 298
Groundhog, 115, 120, 292
Grouse, 52, 115, 119, 136
Guano, 134
Guava, 168
Guinea hen, 163, 360
Guinea pig, 162, 303, 305, 316*f.*, 319
Gulls, 134, 139

Habits, readaptation through change in, 58
Haddock, 52
Hæmophilia, 326
Hair, 364*f.*, 377*ff.*, 412
Halibut, 52
Hare, 269, 278
Hawks, 124*f.*, 137, 139, 140, 273
Hay, 176
Head-form. *See* Race, criteria of.
Health, 79*ff.*, 412*ff.* *See also* Disease; Morbidity; Death rate.
Heath hen, 119, 273
Heidelberg man, 382
Helium, 7, 10, 11, 13
Hemlock, 50, 258
Hemp, 170
Heredity, Chap. XI; acquired characters and, 279, 313*ff.*, 360*ff.*; environment and, 310*f.*, 315*ff.*; mechanism of, 305*ff.*; Mendelian explanation of, 301*ff.*; problems of, Chap. XII. *See also* Sex.
Hermaphrodite, 357*f.*, 360.
Heron, 134, 139
Herring, 98
Hibernation, 58
Homicide, 429
Homunculus, 299*f.*
Honey, 165
Hoof and mouth disease, 235
Hookworm, 223*f.*
Hormones, 359, 362

Horse, 49, 50, 151*f.*, 154*f.*, 235, 250, 277, 278

Humming bird, 115, 119*f.*

Hybrid, 272, 277, 302*ff.*, 324*ff.*, 360. *See also* Race mixture.

Hydra, 291

Hydrogen, 8, 10, 12, 13, 16

Hydrophobia, 209, 235

Hypotrichosis, 326

Ichneumon fly, 103, 285

Ideals, 451

Idiot, 330

Illinium, 7

Imbecile, 330

Immigration, 264, 402*ff.*

Indian, American, 63*f.*, 71*ff.*, 377*ff.*, 401*f.*

Industry, 412*ff.*

Influenza, 231, 235

Inheritance. *See* Heredity.

Insanity, 324, 333, 336*ff.*, 369, 429

Insects, aquatic, 101*f.*; as pollen distributors, 96*ff.*; disease and, 143, 206, 209; domesticated, 164*f.*; enemies of, 136*f.*, 138, 234; habits of, 103*f.*, 105*f.*, 108; in relation to man, 112, 126, 127*ff.*, 132*f.*, 133, 145*f.*; increase in wet seasons, 49

Inorganic compounds, 30

Institutions, change and, 445*ff.*; classification of, 439; serve needs, 443*ff.*; social control through, 440

Intelligence, distribution of, 341*ff.*; family status and, 343*f.*; rest of, Negro and, 394*ff.* *See also* Genius.

Interests, four major, 439

Intermarriage, 328, 333. *See also* Race mixture.

Invar, 184

Inventions, electrical, 197; history and significance of, 178*ff.*, 200; of engines, 194

Invertebrates, 291

Iodine, 21

Iridium, 181

Iris, 129

Iron, 7*ff.*, 22, 180*ff.*, 183, 184*f.*, 185*f.*, 230, 262

Jackal, 160

Jay, 124

Kangaroo, 276, 292

Katabolism, 365

Kerosene, 191

Kingbird, 107, 134, 137

Kingfisher, 359

Koch's postulates, 210

Krypton, 11*f.*

Labor, division of; on sex basis, 370*f.*

Land, agricultural, available area, 243*ff.*; productivity of, 243; utilization of, in U. S., 247*ff.*, 263

Land areas, distribution of, 19*f.*; potential use of, in U. S., 251; reclamation of, 247; utilization of, in U. S., 249

Larkspur, 50

Laurel, 175

Lava, 19*f.*

Lead, 13, 22, 180, 188, 412*f.*

Leather, 176

Leech, 358

Legumes, 90

Lemon, 167

Lemur, 288*f.*

Lentil, 167

Lettuce, 167
Lice, as medical remedy, 216; body, 132; carriers of typhus, 225; plant, 108
Lichens, 94
Life, balance of, 99*ff.;* beginning of, 31*ff.;* dependent on carbon, 36*f.;* dependent on oxygen, 37*f.;* dependent on water, 36; fossil evidence of, 273*f.;* geographical distribution of, 275; increase in span, 232; infinite variety of, 269*ff.;* ladder of, 291*f.;* nature and distribution of, Chap. II. *See also* Evolution; Nature; Organisms.
Light, artificial, 191; reactions of organisms to, 53
Light years, 4
Limestone, 9, 22
Linked characters, 309*ff.*
Lithium, 11*f.*
Liver worms, 95
Lizard, 142, 292
Llama, 161
Lobster, 116, 291, 297
Loco weed, 50
Locusts, 101, 106
Lumber, 258. *See also* Forest.
Lynx, 114

Macaw, 119
Machines. *See* Engines; Inventions.
Magnesium, 7, 8, 9, 11, 90, 187
Maize, 167, 168
Malaria, 49, 50, 103, 143, 212, 230; history and control of, 220*ff.*
Male. *See* Sex.
Malthus and Malthusianism, 242*f.*, 263*ff.*, 280
Man, a disturbing factor, Chap. V; adaptation to environment, 61*ff.;* early remains of, 381*ff.;* major interests of, 438*f.;* normal or ideal, 323*f.;* physical imperfections, 431*f.;* place of origin, 62, 381; unit characters, 324*ff.* *See also* Evolution; Body, human; Race; Heredity.
Manganese, 8, 11, 184, 186
Mango, 169*f.*
Manioc, 168, 170
Marriage rate, 264, 417*ff.*
Marsupials, 292
Marten, 121
Martin, 58
Masurium, 7
Matches, 191
Matter, concept of, 28, 30; motion characteristic of, 27; nature of 7*ff.*
Maturation, 362
Meadow lark, 52, 120, 137
Measles, 210, 426
Medicine, ancient, 204*ff.;* antisocial selection of, 414; early, 202*ff.;* magic and, 204; preventive, 230*f.* *See also* Disease; Surgery and various diseases.
Mediterranean race, 383
Melon, 167
Menopause, 367
Menstruation, 367, 412
Mental activities, geographic environment and, 75*ff.*
Mental inferiority, 329*ff.;* alleged, of women, 368*f.;* race and, 392*ff.*
Mental tests. *See* Intelligence, tests of.

Mercury, derived from lead, 13, 30, 180, 206, 230
Mesozoic age, animals of, 292
Metabolism, sex and, 365*ff.*, 369
Metals, history and use of, 179*ff.*; limited supply of, 181*f.*, 261*f.*
Meteorites, 7, 23, 180
Mice, 97, 101, 125, 139, 140, 160, 216, 312
Microörganisms, 87*f.*
Microscope, 87
Migration, birth rate and, 422; geographic influences and, 74*f.*; preliterate, 381, 385. *See also* Population, movements of.
Milk, 224*f.*, 252
Millet, 167
Mink, 115, 121, 124
Mitosis, 296, 298, 307
Moccasin snake, 117
Molds. *See* Fungus.
Mole, 53
Molecules, 28, 30
Mollusks, 98, 102
Molybdenum, 189
Mongolian idiot, 332
Mongoose, 142
Monkey, 278, 289
Moon, 18
Morals, 433, 441. *See also* Standards, group; Ethics.
Morbidity, sex and, 365*ff.*
Moron, 330*f.*
Mosquito, 95, 98, 103, 143, 217*f.*, 222*f.*, 230
Moth, 54, 100, 131*f.*; brown-tailed, 130*f.*; coddling, 132; gypsy, 55, 130*f.*; tussock, 103; yucca, 97
Mountains, distribution of water and, 44*f.*
Mulatto, 397*ff.*
Mule, 151*f.*, 155*f.*
Murder, 429
Musical ability, inheritance of, 346
Musk ox, 121
Muskrat, 115, 121
Mussels, 116
Mutation, 300, 309, 311, 375
Mutilations, and heredity, 315
Mutual aid, Chap. IV, 109*f.* *See also* Association.

Nasal index, 385
Natural selections, 284. *See also* Selection, biological.
Nature, balance of, 99*f.*, 211*f.*; balance of, disturbed, 112*ff.*, 133*ff.*; rhythm in, 59*f.* *See also* Geographic environment; Life; Organisms.
Neanderthal man, 382
Nebulæ, 5
Nebular hypothesis, 31. *See also* Earth, origin of.
Nectarine, 311
Negro, climatic adaptation of, 63*ff.*; mentality of, 392*ff.*; mulatto, 397*ff.*; racial characters of, 377*ff.*
Neon, 11
Nervous inferiority, 329*ff.*
Neurasthenia, tropical, 67
Nickel, 8, 181, 184, 186
Niton, 12
Nitrogen, 7, 8, 11, 13, 23, 56, 86, 90
Nitrous oxide, 228
Nordic race, 383*f.*, 388*f.*, 402*ff.*
Nucleus. *See* Cell.

Oak, 297
Oats, 54, 168, 234, 253

Occupation, ability and, 343*f.;* geographic environment and, 71*ff.;* sex and, 370*ff.*
Olive, 167
Onion, 167
Operations, surgical, 229*f.*
Opium, 426
Opossum, 115, 120, 121, 141, 292
Opuntia, 175
Orange, 167, 260
Orang-utang, 288
Organic compounds, 30*ff.*, 39*f.*, 89*f.*
Organisms, activities of, 55*ff.;* as chemical engines, 38*ff.;* checks on increase of, 99*ff.;* classification of, 45; dependence of higher on lower, 291; phosphorescent, 59*f.;* physical environment of, 40*ff.;* reactions to light, 53; structure of, 31*ff.;* temperature and, 34*f.* *See also* Life.
Oriole, 137
Otter, 115
Ostrich, 164
Ovary, transplanted, 319
Ovum, 57, 298*ff.* *See also* Sex.
Owl, 52, 53, 58, 124, 125, 139, 140
Oxygen, 7, 8*f.*, 10, 11, 16, 23, 37*f.*, 56
Oyster, 116
Oyster shell scale, 132
Ozone, 54

Paleontology, as evidence for evolution, 286*f.*
Paleozoic age, animals of, 292
Pangenesis, 282*f.*
Parakeet, Carolina, 119
Paramecium, 99
Parasitism, 93*ff.*, 103*f.* *See also* Insects; Nature, balance of.
Parrot, 119
Parthenogenesis, 358
Partridge, 278
Pea, 90, 167
Peach, 167, 234
Pear, 168, 234
Pelican, 107, 116
Pendulum, 184
Peony, 174
Petroleum, 22, 197*f.*
Pewee, 137
Peyote, 426
Pheasant, 360
Philanthropy, selection and, 428*f.*
Phlogiston, 10
Phosphorescent organisms, 59*f.*
Phosphorus, 8, 11, 22, 90*f.*, 186
Phylloxera, hickory, 358
Pickerel, 102
Pigeons, domestic, 124, 164; passenger, 107, 120, 136, 286
Pigmentation. *See* Eye color; Hair; Skin color.
Pigs. *See* Swine.
Piltdown skull, 382
Pine, 132, 233, 258
Pineapple, 168
Pithecanthropus erectus, 381*f.*
Pituitary. *See* Glands, ductless.
Planetary theories, origin of life and, 31*f.* *See also* Earth, origin of.
Planets, 3*f.*, 18
Plantain, 126
Plant lice, 108, 358
Plants, adaptation to environment, 56*ff.;* composition of, 34; domestication of, 113; food habits of, 103; importance in the organic complex, 86*f.;* orna-

mental, 174*f.*; poisonous, 50; purposeful breeding, 260*f.*; reproduction of, 358; served by animals, 96*ff.*; temperature and distribution, 51; useless destruction, 144; water requirements and distribution, 46*ff.*, 86. *See also* Domestic plants.
Platinum, 21*f.*, 181, 188*f.*
Plover, 119, 145
Plow, 182
Plum, 167, 168
Pneumonic plague, 227
Political institutions, 438*f.*
Pollen, distribution of, 96*ff.*
Polydactilism, 326*f.*
Polyp, fresh water, 94
Poppy, 174
Population, checks on, 263; food supply and, Chap. IX; limit in U. S., 262*ff.*; movements of, 238*ff.*, 240*f.*; net increase, 421; problems of, 415*ff.*; standard of living and, 239; world distribution, 68*f.*, 237; world increase and limit upon, 243*ff.*
Porpoise, 56
Potash, 261
Potassium, 8, 9, 11*f.*, 90
Potato, sweet, 167, 168, 234; white, 127, 139, 168, 169, 234, 253
Pottery, 179
Poultry, protection of, 124*f.*
Power, from atom, 28; wind and water, 196. *See also* Fuel.
Prairie chicken, 119, 273
Prairie dog, 91, 115, 138
Praying mantis, 106, 284
Prawn, 297
Pressure, effects of. *See* Altitude.
Primates, 288
Primitive artifacts, 178*ff.*
Primrose, evening, 300*f.*
Progress, concept of, Chap. XVII; cost of, Chap. XVIII; criteria of, 453*f.*; difficulty of definition, 449*ff.*; illusion of finality, 464; not inevitable, 462
Protein, 33, 37, 90
Protoplasm, 32*ff.*
Protozoa, 87; symbiosis and, 93*f.*
Puberty, 364*f.*
Pulp wood, 259
Puma, 114, 123
Pumpkin, 127, 188

Quail, 52
Quince, 167
Quinine, 173*f*, 230

Rabbit, 107, 115, 138, 142*f.*, 162, 269, 317, 359
Rabies, 209, 235
Race, Chap. XIV; ability and, 392*ff.*; climate and, 63*ff.*; criteria of, 380*ff.*, 387*ff.*; early remains, 381*ff.*; early use of term, 376*f.*; meaning of term, 375*f.*; mixture, 386, 387*f.*, 397*ff.*; 405*f.*; modern classifications, 383*ff.*; possibility of accurate classification, 404*ff.*; prejudice, 390*ff.*, 402*ff.*; some attempts at classification, 377*ff.*
Raccoon, 115, 120, 121, 141
Radioactive substances, 6, 13
Radiolarians, 94
Radish, 167
Radium, 10*f.*, 11, 13, 130
Rainfall, 44*f.*, 47*ff.*

Rat, 124, 139*f.*, 142*f.*, 162, 234, 298
Rattlesnake, 117
Raven, 139
Rays, various types of, 28. *See also* Radium; X-ray.
Redwood, 258
Reindeer, 106*f.*, 159
Religion, 436, 438, 439, 447. *See also* Church.
Remora, 95
Reproduction, 40, 98*ff.*, 296*f.* *See* also Sex.
Reptiles, 117, 162, 275
Research, social, 458; tradition and, 460*f.* *See also* Science.
Resources, standard of living and, 239*f.*
Rhenium, 7
Rhinoceros, 122
Rhododendron, 175
Rhythm, in nature, 59*f.*
Rice, 167, 168, 240
Rivers, 20, 56*f.*, 116
Robin, 52, 98, 120, 134, 137
Rocks, 24*f.*
Rodents, 124*f.*, 138
Roman law, influence on status of women, 372
Rose, 174
Royalty, ability of, 346*ff.*
Rubber, 168, 172*f.*
Rye, 168, 253

Salamander, 292, 319
Salmon, 115*f.*
Salts, leached from soil, 22*f.* *See also* Water areas.
San Jose scale, 131
Sand, moved by wind, 18*f.*
Scale insects, 131
Scandium, 11
Science, limitations of, 450; progress of, 485*f.* *See also* Research.
Sea anemone, 94
Sea cucumber, 94
Selection, alcohol and, 316*f.*; biological, 278*ff.* *See also* Birth rate.
Sewage, 176
Sex, determination, 361*f.*; differentiation, 358*f.*; growth and, 363*f.*; in lower organisms, 357*f.*; mental ability and, 368*f.*, 389*f.*, 393*f.*; physical differences, 363*ff.*, 403; ratio, 360*f.*; social influences on status, 369*ff.*; special functions, 367*f.*
Sex-linked characters, 312, 325*f.*
Sexual selection, 282*f.* *See also* Selection, biological.
Shad, 115*f.*
Shark, 52, 95, 292
Sheep, 50, 102*f.*, 151*f.*, 156*f.*, 235, 263, 278, 311, 312
Silicates, 9
Silicon, 8*f.*, 12, 184, 186, 189
Silk, 165*f.*; disease of silkworm, 208
Silo, 176
Silver, 7, 21*f.*, 179*f.*; German, 181
Skin color, climate and, 63*ff.*; of old Americans, 403; race and, 377*ff.* *See also* Mulatto.
Skunk, 121, 124, 139, 141
Slavery, 467
Sleep, 58
Sloth, 276
Smallpox, 208, 212*ff.*, 231, 317
Snails, 53, 290, 358
Snakes, 117, 273, 292
Snow, 43*f.*, 49*f.*

Social change, 445*ff.* *See also* Progress.
Social control, 440
Social problems, due to change, 466*ff.;* panaceas for, 473*ff.*
Society, concept of, 435*f.* *See also* Association.
Sodium, 8, 9, 11
Soil, fertility and bacteria, 90; formation and types, 25; improved by small animals, 91. *See also* Land, agricultural.
Solar system, 3*ff.*
Sorghum, 167
Sound, 28
Sow bugs, 132
Soy bean, 167, 260
Spanish moss, 47
Sparrows, 134*ff.*, 141
Species, 272; geographical distribution, 290. *See also* Evolution; Life.
Spectroscope, 6, 10
Spermatozoön, 296. *See also* Heredity, mechanism of; Sex.
Spiders, 106, 358
Spinach, 167
Spontaneous generation, 207
Sports, 301
Spruce, 132, 174
Squash, 168, 311
Squirrels, 91, 97, 115, 138, 228
Standard of living, 239f., 241, 244
Standards, group, 436*f.*
Starch, 33
Starfish, 297
Starling, 142
Stars, 3*ff.*
Steel. *See* Iron.
Sterility, alcohol and, 316*f.* *See* also Birth rate.
Sterilization, of the unfit, 352*f.;* sex differences and, 359
Stove, 194*f.*
Strawberry, 126, 168
Streams. *See* Rivers.
Strontium, 8
Sugar, 37, 171*f.*, 412
Sugar cane, 167
Suicide, 429
Sulphur, 8, 12, 90, 184
Sun, 5*f.*, 64*f.*, 261
Sunfish, 98
Superstition, 202, 446; medicine and, 205, 216
Suprarenals. *See* Glands, ductless.
Surgery, anti-social selection of, 414; equipment and, 182; fees at Babylon, 203*f.;* mortality in, 229*f.* *See also* Disease; Medicine.
Swan, 107, 118
Sweet pea, 174, 301*f.*
Swine, 151*f.*, 158, 234*f.*, 250, 252*f.*, 263, 273
Symbiosis, 93*f.*
Syndactylism, 326
Syphilis, 206, 230, 423

Tantalum, 189
Tapeworm, 95, 211
Tarbagan, 228
Tea, 167, 174
Teeth, 412
Telescope, invention of, 4
Temperature, influence of, 50*ff.* *See also* Climate.
Temperature control, law of, 50*f.*
Teredo, 133
Termites 93, 132
Tern, 119*f.*

Terrapin, 115*f.*
Tetanus, 211, 231
Texas fever, 98
Thallium, 13
Theology, science and, 270*ff.*
Thistle, Canada, 126
Thorium, 191
Thrasher, brown, 134, 137
Thymus gland, 332
Thyroid gland, 332, 367. *See also* Glands, ductless.
Ticks, 48*f.*, 95, 98, 142, 286
Tiger, 112, 276
Tile fish, 52*f.*
Timber. *See* Forest.
Timothy, 168
Tin, 22, 179*f.*, 182, 186, 187*f.*
Titanium, 8, 11
Toad, 216
Tobacco, 168, 174, 253
Toe, degeneration of, 412
Tomato, 168, 170
Tools, influence of, 411; primitive, 178*ff.* *See also* Inventions.
Topography, 40*ff.*, 86
Toucan, 52
Transmutation of metals, 10
Trichina, 234
Trout, 56
Tsetse flies, 49
Tuberculosis, 204, 209, 212; among animals, 234*f.*; deaths from, 231; importance and control of, 225*ff.*; industry and, 413
Tungsten, 181*f.*, 185, 189, 194
Turkey, 115, 163
Turkey buzzard, 116
Turnip, 167
Turtle, 115
Typhoil fever, 67, 143, 224*f.*, 231
Tyhus, 224

Universe, earth centered, 4, 271
Unit characters, 306, 309*ff.*, 324*ff.*
Uranium, 13

Vaccination. *See* Smallpox; Typhoid fever.
Vanadium, 11, 185
Variation, biological, 276*ff.*, 301, 369
Variety, 273, 275. *See also* Race; Species.
Vertebrates, 292
Vestigial structures, 290*f.*
Vinegar, 176
Vital principle, 30, 34, 39
Volcanic phenomena, 6, 9, 19, 20
Volvox, 357*f.*
Vulture, 134

War, population and, 240*f.*; selective influence of, 426*f.*
Wasp, 360
Water, as solvent, 21*f.*, 36; chemical analysis of, 10; disease carrier, 49; distribution of, 43*f.*; influence of size of earth and temperature on, 18; once all fresh, 21; penetrating powers, 36; per cent of earth's surface, 23; power source, 196; regulating temperature, 35*f.*; stability of the earth's supply, 18
Water areas, distribution of, 19*f.*; salt content and deposits, 21; temperature of, 42*f.*
Water flea, 211
Watermelon, 168
Weasel, 115, 121, 124, 139, 161
Web of life, 95. *See also* Association; Nature, balance of.

Weeds, 126, 135*f.*

Weevil, alfalfa, 137; cotton boll, 128, 137

Whale, 56, 107, 273

Wheat, early use of, 167*ff.;* exports of, 255; production and rainfall, 48; dust, 233*f.;* selective breeding of, 260; waste in flour, 240; weeds and, 126; yield, 253

White race, climatic adaptation of, 63*ff.;* racial characters of, 377*ff.*

Willow, 51, 296

Wind, as power source, 196; changing earth's surface, 18*f.;* climate and, 43*f.;* distribution of life and, 54*f.* *See also* Climate.

Wine, 176

Wolf, 50, 114*f.*, 121, 123, 160, 276, 292

Woman, in industry, 412*f.;* social position of, 369*ff.* *See also* Sex.

Woodpecker, 137, 273

Work, monotony of, 413*f.* *See also* Industry; Occupation.

Worms, army, 103, 127; chromosomes of, 298; cut, 136; grub, 137; guinea, 206; hermaphroditic, 358; in ladder of life, 291; influence on soil, 91, 281; nematode, 360; orchard, 103; reproduction of, 297; silk, 165*f.;* spring canker, 141; spruce-bud, 132; tomato, and natural selection, 285

Wren, 58, 134

Xenon, 12

X-ray, 28, 317

Yak, 154

Yeast, 88, 176

Yellow fever, 143, 212, 216*ff.*

Zebu, 154

Zinc, 22, 180*f.*, 186

Zirconium, 189

Zones of life in North America, 51

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